Sphingomyelin in the Brain and Cognitive Development

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Objectives

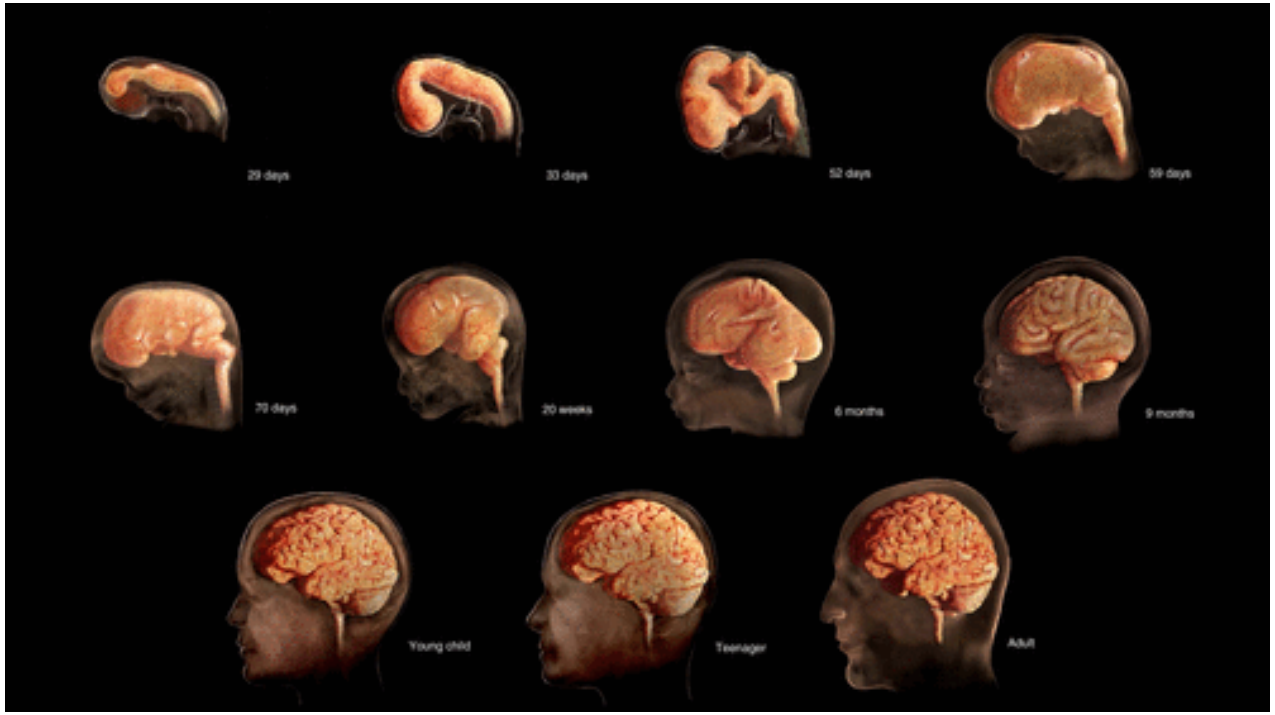
At the end of the session, participants will be able to:

- Understand the development of the nervous system
- Appreciate Infancy and early childhood as critical windows of opportunity for child development
- Understand the role of Sphingomyelin in brain development

- Appreciate the emerging evidence of sphingomyelin as a vital nutrient for cognition and learning in early life.

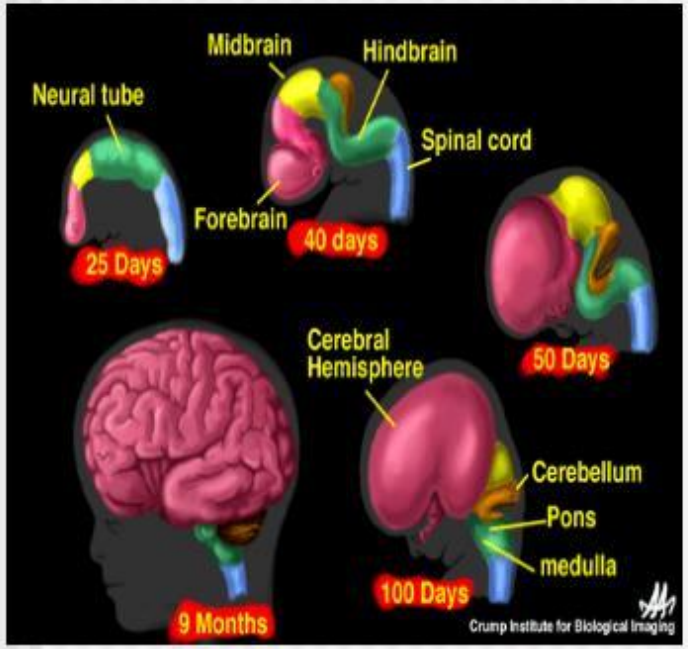
Development of the Nervous System

- The fetal nervous system is one of the first systems to be developed and the last to be completed after birth.
- The process generates the most complex structures within the embryo
- At birth, the brain is at 25% of adult size but reaches 75% of adult size by the end of the first year.



Early life: a key period

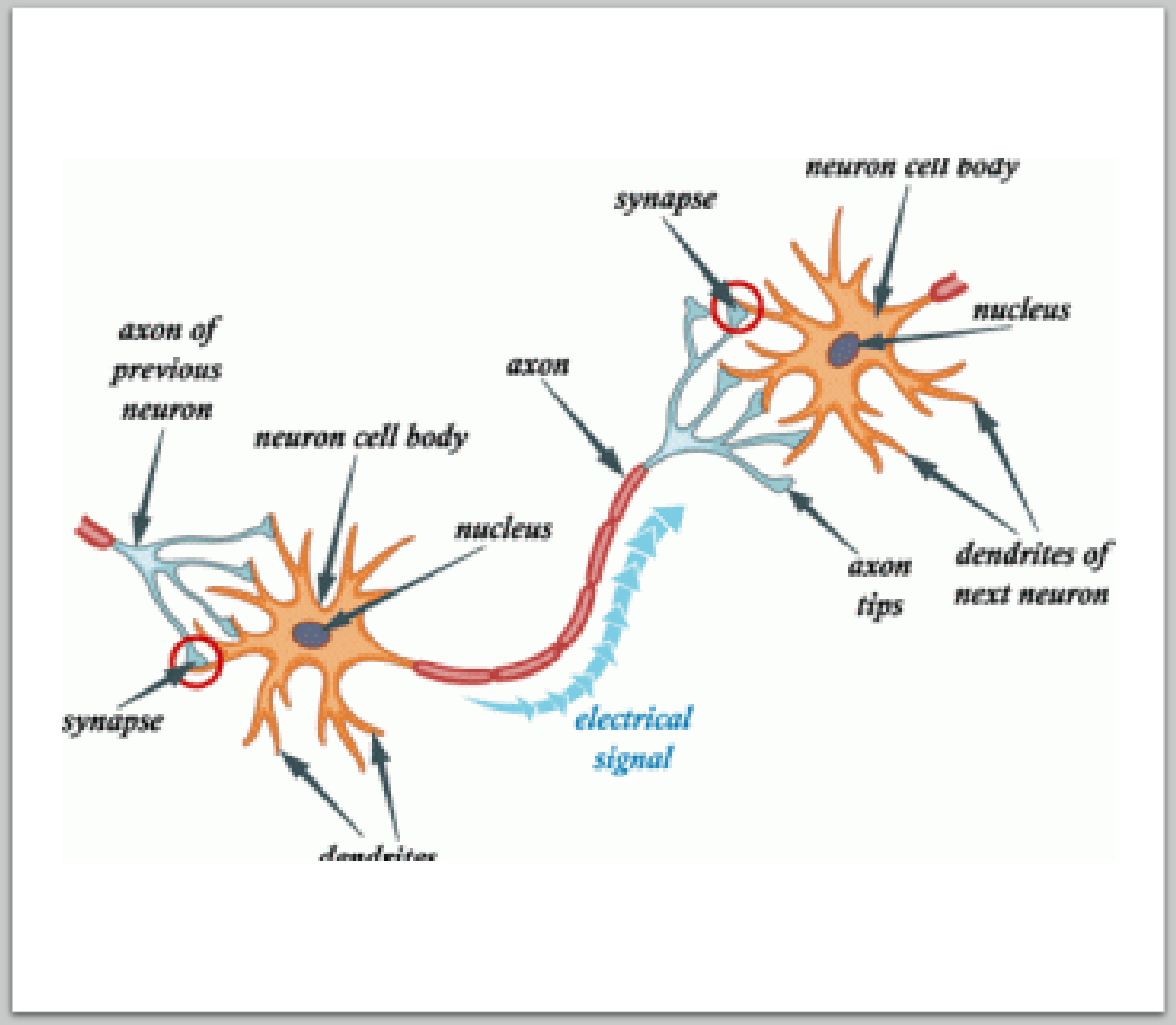
Brain Development



- 3rd week of pregnancy
- 17th week of gestation
- 24th week of gestation
- The last trimester
- Between birth and 8 months

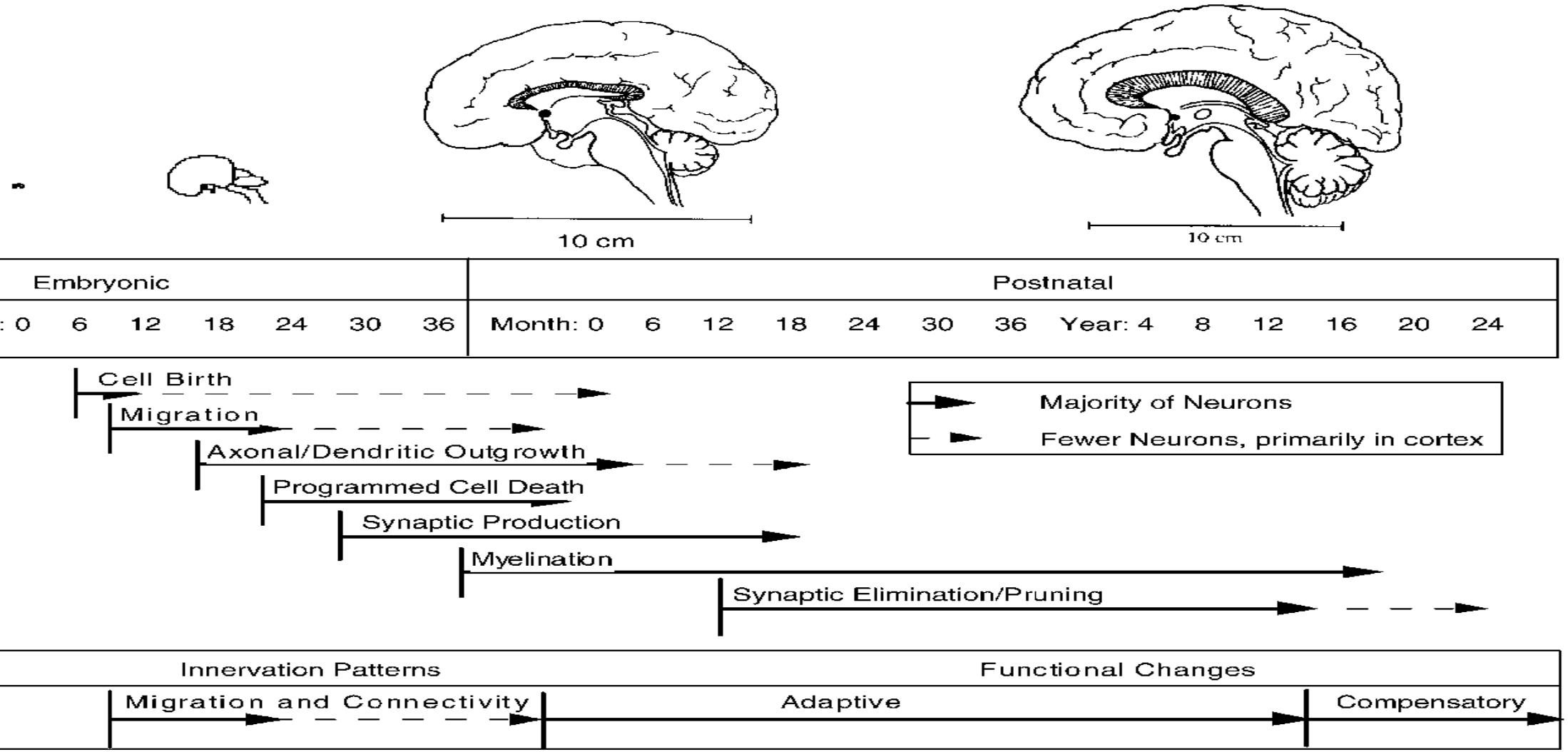
Early life: a key period for brain Development

- A newborn baby has all the **neurons** that he/she will have for the rest of his or her life
- Brain growth after birth is mainly by the formation of millions of **synaptic connections**
- These connections between the neurons are what make the brain work!



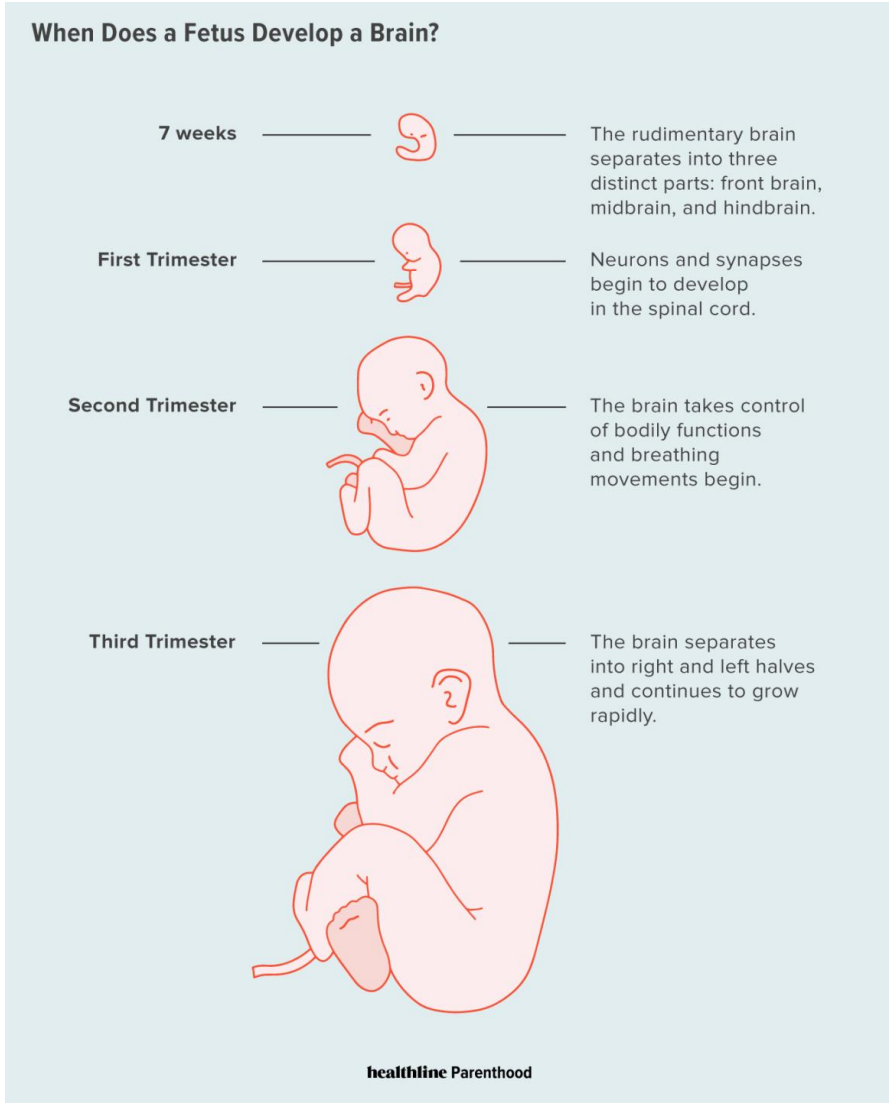
Stages of Brain Development

Stages of Brain development



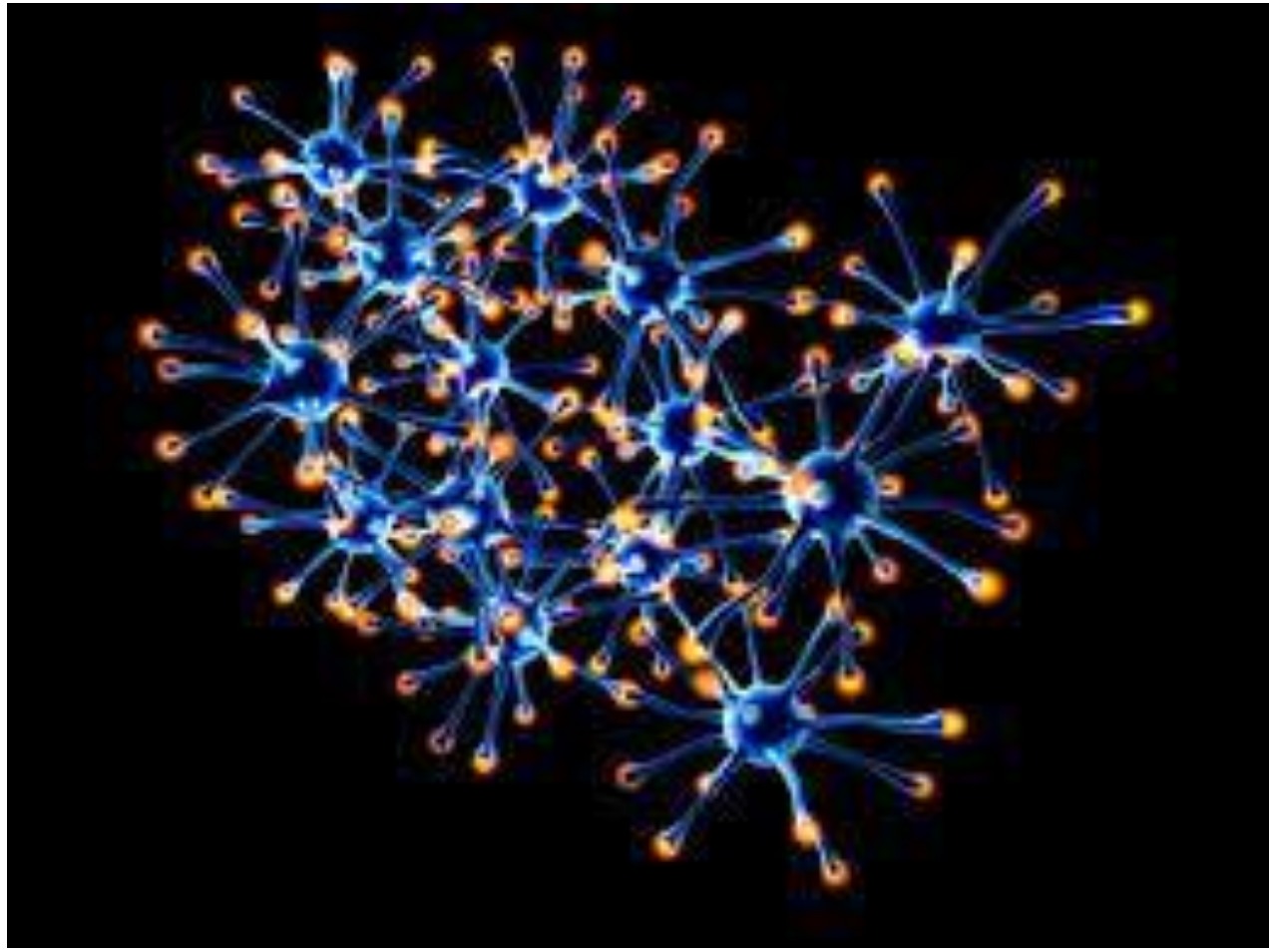
Phase 1

- Occurs in first half of gestation and characterized by:
  - Creation of new neurons at rates up to **250,000 neurons/minute**
  - **Migration** towards the outer surface
  - **Cortical growth**, both in thickness and surface area



Phase 2

- From mid-gestation to 2 years and characterized by:
  - Neuronal **migration**
  - Neuronal **connectivity**

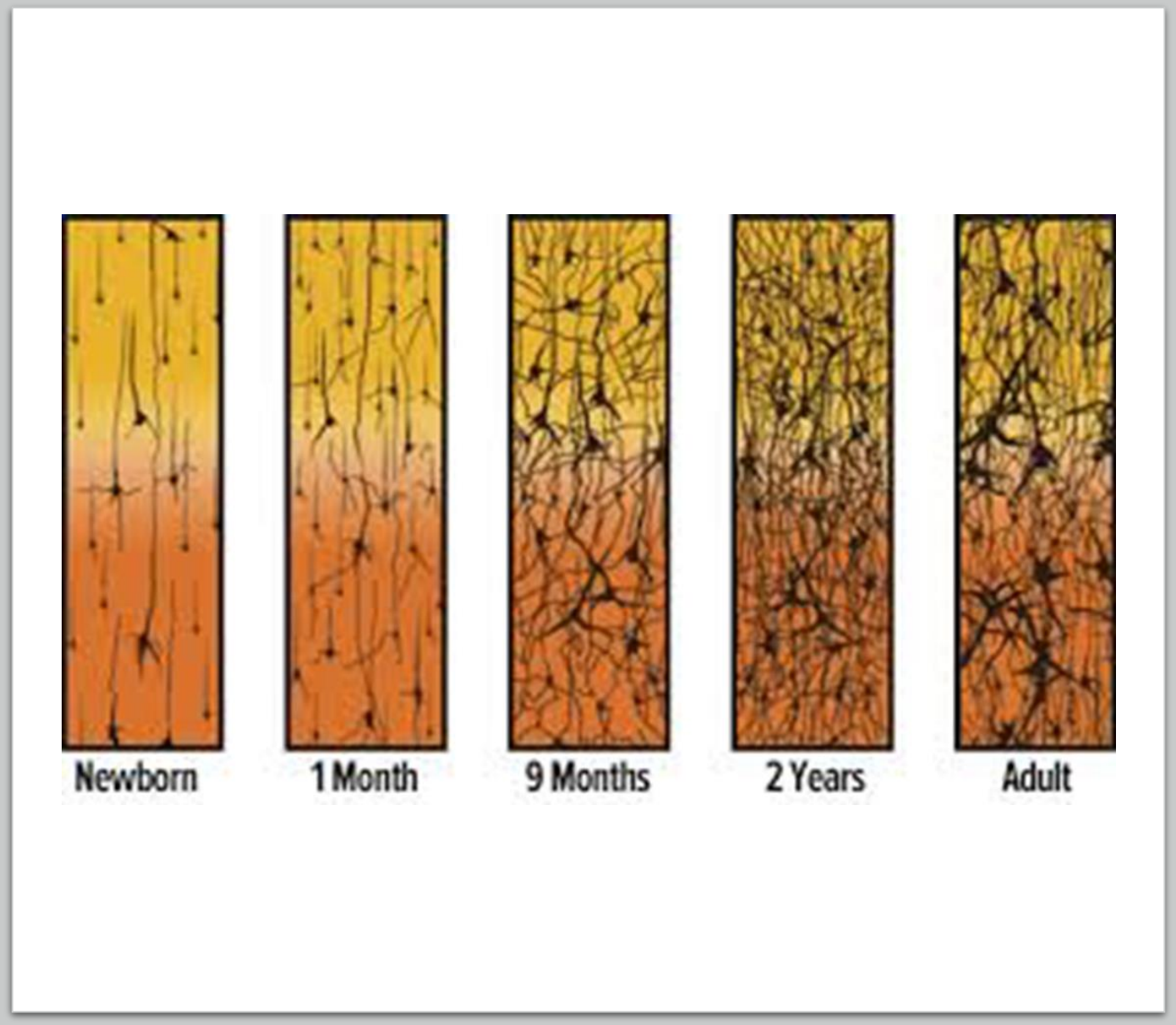


Key Factors in Brain Development

- **Genetic factors (nature):**
  - Regulatory genes
- **Environmental factors (nurture):**
  - Nutrition
  - Emotional stability
  - Mother's health
  - Social environment
  - Etc.

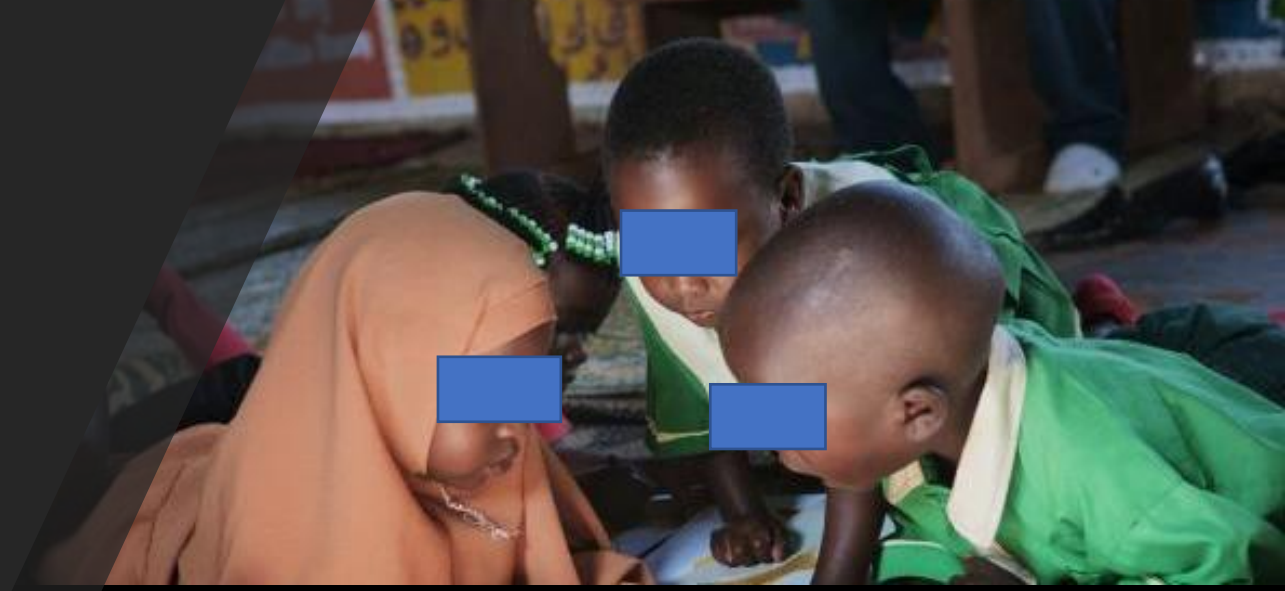
Learning in Infancy and Early Childhood

- The brain forms and refines a complex network of connections by synaptogenesis, pruning & myelination
- Pruning is a key process that shapes the brains of young children:
  - Getting rid of wasteful neural connections and damaged neurons in order to strengthen the important ones.



Learning:

the process of creating and strengthening frequently used synapses!



Infancy and early childhood: critical window for brain growth and development

The developing brain is peculiarly vulnerable to modification by environmental factors

The quality of **nutrition** in early life significantly impacts the quality of brain development

Nutrition can directly influence and support the CNS through changes in the neuroanatomy and neurotransmission

Brain Lipids

- Play a critical role in brain structure and function.
- The nervous system is one of the tissues with the highest lipid contents and the highest lipid complexity.

5 major phospholipids in the brain

Sphingomyelin

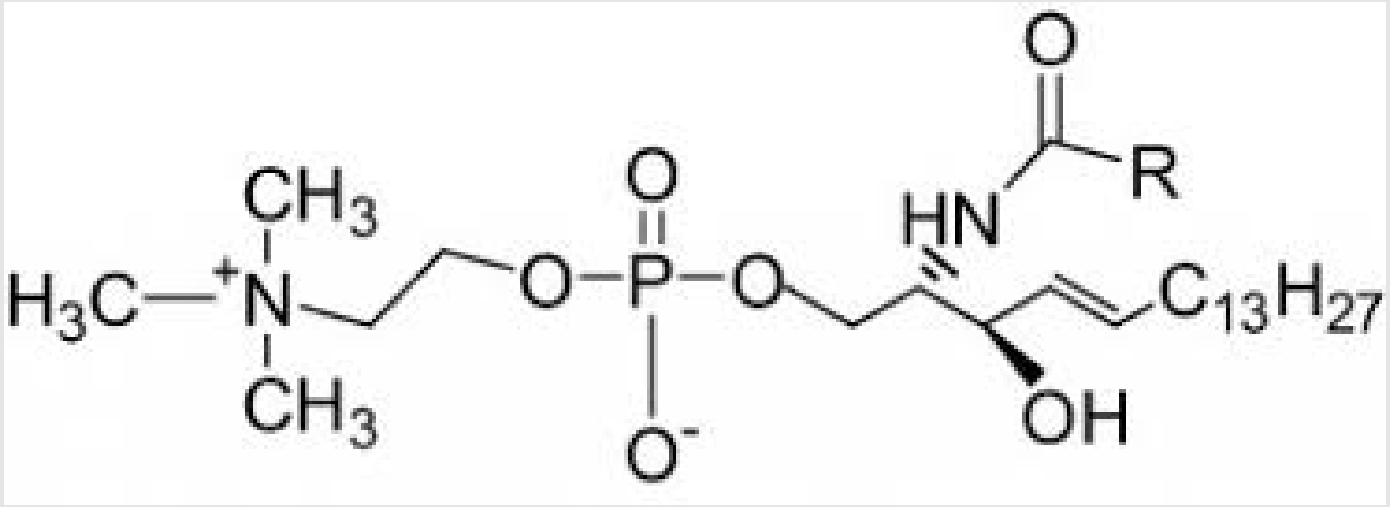
Phosphatidyl-ethanolamine

Phosphatidyl-choline

Phosphatidyl-inositol

Phosphatidyl-serine

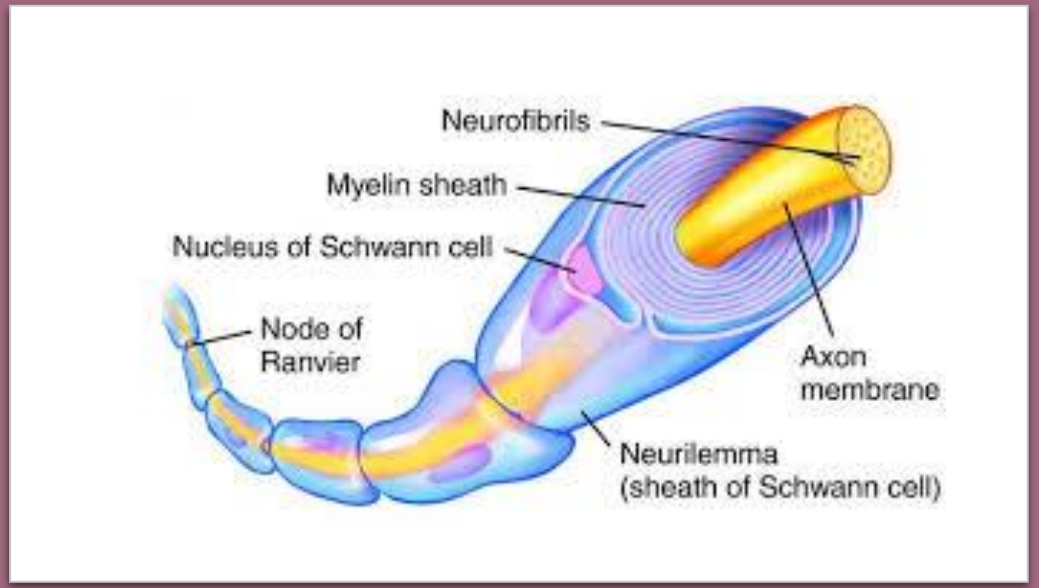
Brain Lipids: Sphingomyelin

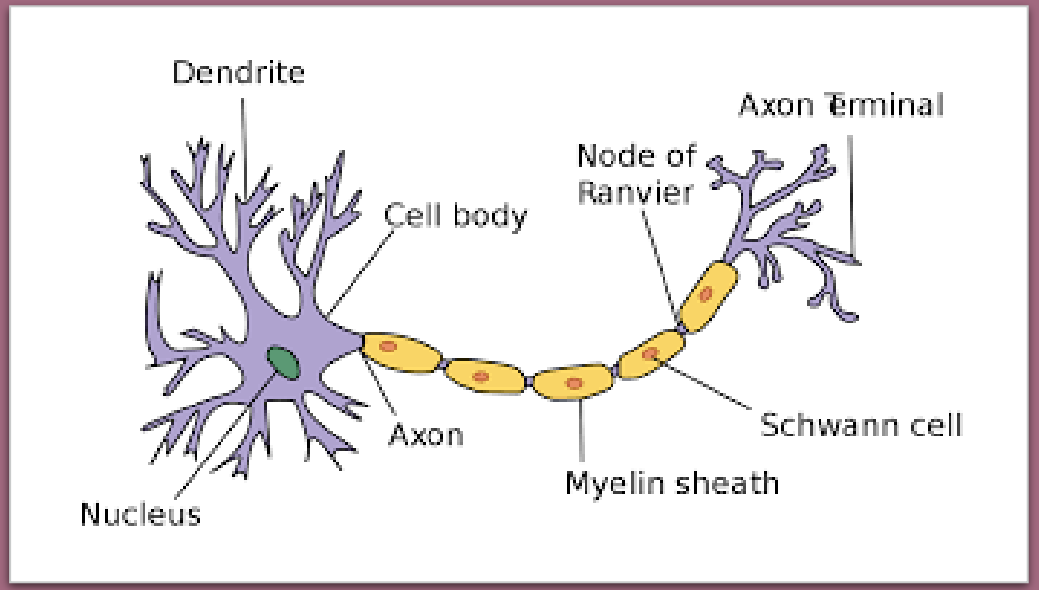


- A structural building block in the brain
- The most abundant phospholipid in human milk
  - By the age of 4 weeks, SM accounts for 35% of phospholipids in human milk

Sphingomyelin

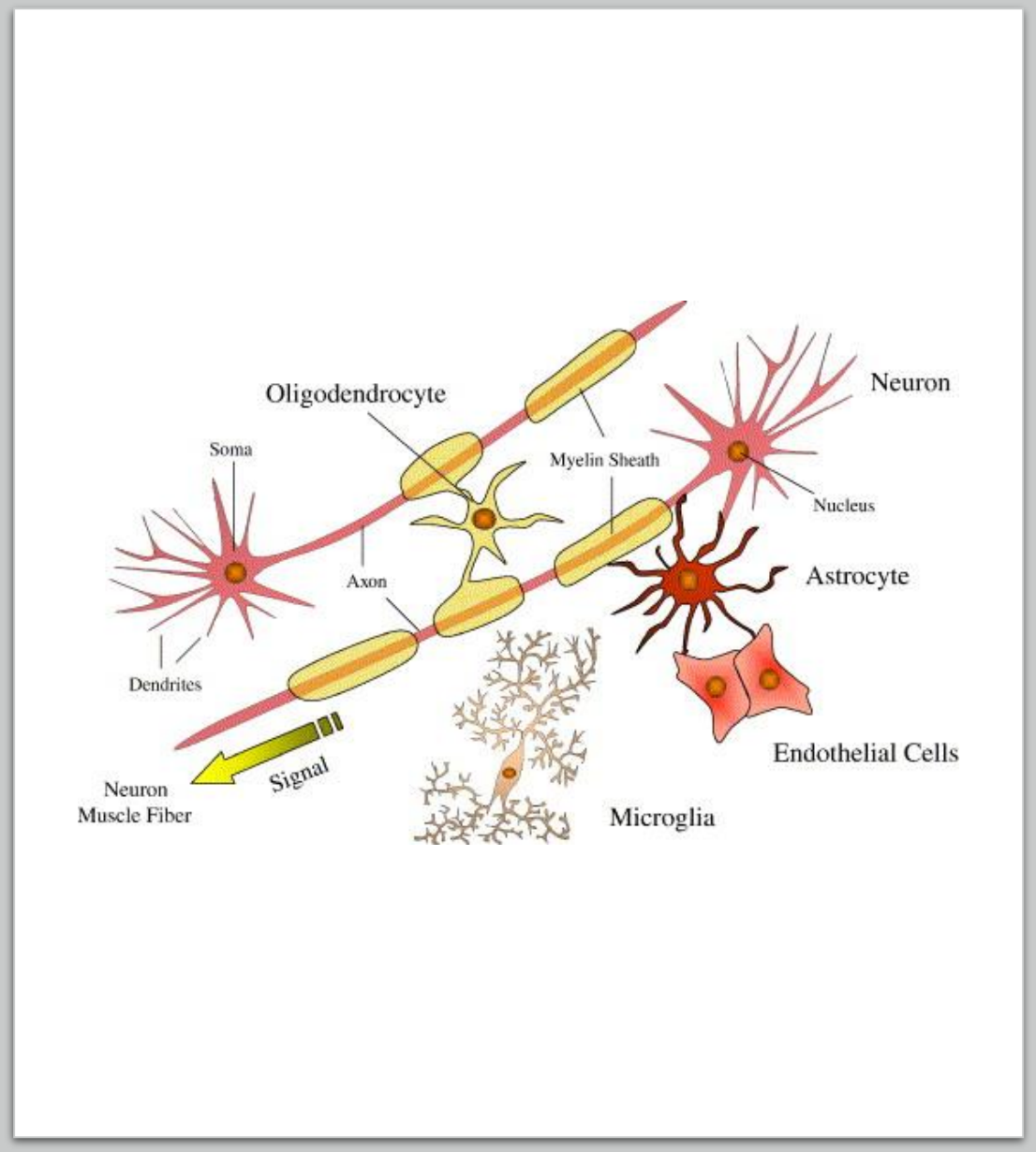
- SM is a key component of the **myelin sheath**
- Myelin ***protects*** the neurons
- Helps to ***conduct signals*** more efficiently
- ***Prevents erratic activation*** of neighbouring axons





Sphingomyelin

- SM is not just a structural element
- Also a regulator of cellular events- microdomains in plasma membranes
- Plays vital role in the differentiation of neurons, synaptic transmission and neuronal-glial interactions

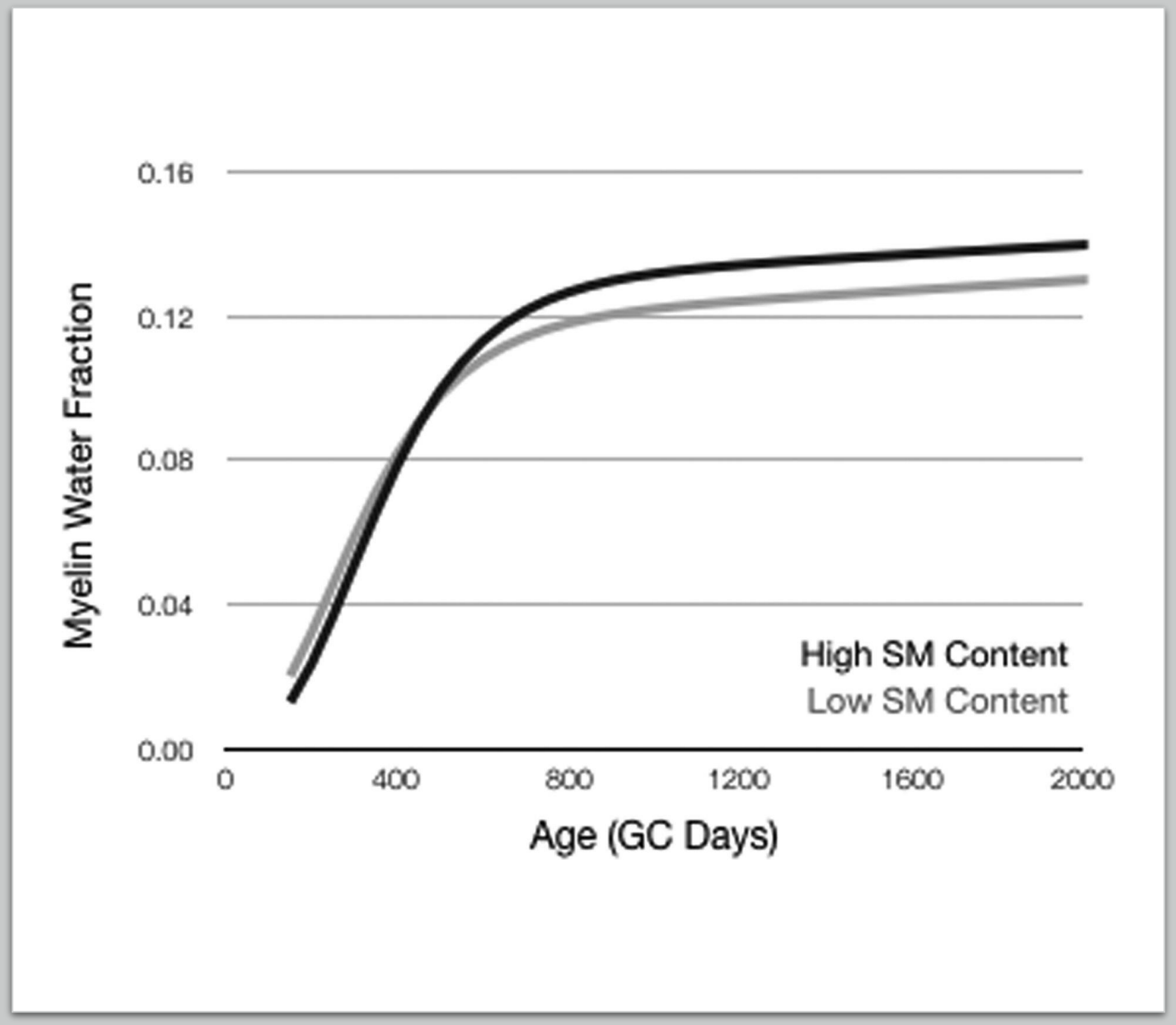


Sphingomyelin

- The brain uses 20% of the total energy requirement of the body
- SM levels in the brain increase from 2% at birth to 15% at 3 years
- The increase is consistent with a progressive increase in neuronal myelination after birth
- Other phospholipids decline or show a modest increase during postnatal development
- **SM and other polar lipids are vital nutrients for:**
  - Brain structure:
    - Myelination, neuronal outgrowth, morphology, plasma membranes
  - Brain function:
    - Synaptogenesis and synaptic transmission
  - Brain metabolism

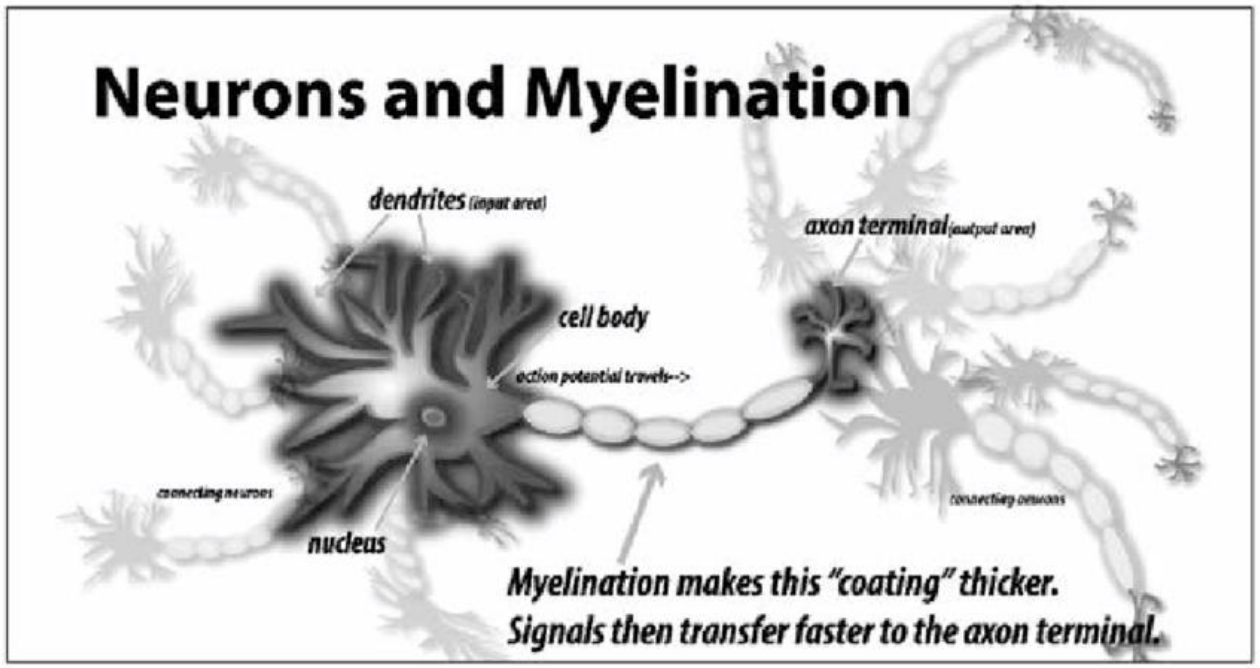
Dietary Sphingomyelin and Brain Myelination

White matter myelination trajectories for children who received a product composition with high SM content (71mg/dl) versus a lower SM content (28mg/dl). An observational study on a cohort of healthy children. The findings indicate an impact of dietary SM on cognitive development in healthy children, potentially modulated by oligodendrocytes and increased axonal myelination



Benefits of Brain Myelination

- Improves general cognitive ability
- Better language and reading ability
- Promotes working memory
- Higher processing speed
- Improved sensory reactivity



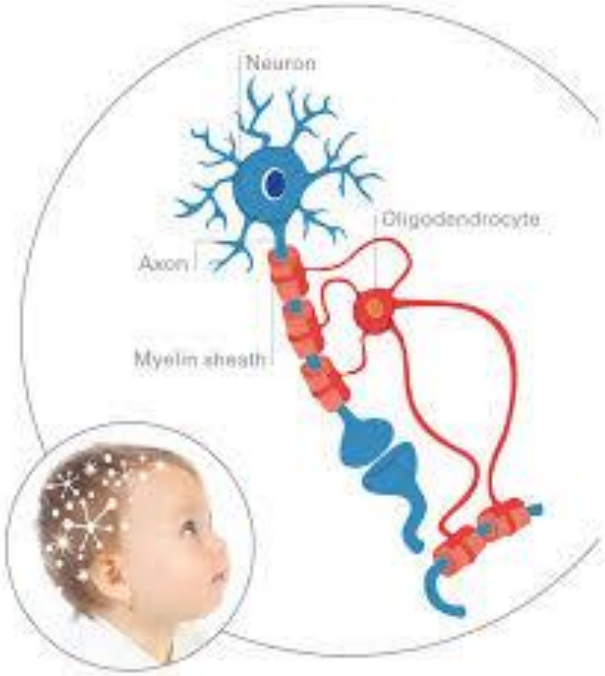
Brain myelination – the key to brain efficiency

- The different parts of the brain have different functions.
- Efficient connectivity is mandatory for proper brain and cognitive functions
- It is the connections between the neurones that make the brain work

SM-fortified milk has a positive association with neurobehavioural development of LBW infants - RCT

- Improved behaviour rating scores on BSID-II
- Better novelty prerefence scores (Fagan test)
- Increases sustained attention scores

Tanaka et al. Brain Devt. 2013




Sphingomyelin in Brain and Cognitive Development: Preliminary Data

CNS myelination is critical for maturation of brain networks!

SM plays an important role in cognitive development via its structural and functional involvement in CNS myelination

Infancy and early childhood are critical windows for brain growth and cognitive development

Malnutrition in the prenatal & postnatal periods may decrease myelin-specific lipids in the brain with major consequences on brain structure & function

Human milk is the preferred source of nutrition for infants and naturally contains sphingomyelin!

Key Messages

The first 3 years of life represent a rapid and dynamic period of brain maturation

Most brain processes during the period are primarily focused on connecting the brain by myelination and formation of new brain connections

Early life nutrition is an important and modifiable factor that can shape myelination and subsequently cognitive outcomes


Thank You

References

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