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Approximate invariance of metabolic energy per synapse during development in mammalian brains

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During mammalian development the cerebral metabolic rate correlates qualitatively with synaptogenesis, and both often exhibit bimodal temporal profiles. Despite these non-monotonic dependencies, it is found based on empirical data for different mammals that regional metabolic rate per synapse is approximately conserved from birth to adulthood for a given species (with a slight deviation from this constancy for human visual and temporal cortices during adolescence). A typical synapse uses about $(7\pm 2)\cdot 10^{3}$ glucose molecules per second in primate cerebral cortex, and about 5 times of that amount in cat and rat visual cortices. A theoretical model for brain metabolic expenditure is used to estimate synaptic signaling and neural spiking activity during development. It is found that synaptic efficacy is generally inversely correlated with average firing rate, and additionally, synapses consume a bulk of metabolic energy, roughly $50-90 %$ during most of the developmental process (except human temporal cortex $ < 50%$). Overall, these results suggest a tight regulation of brain electrical and chemical activities during the formation and consolidation of neural connections. This presumably reflects strong energetic constraints on brain development.

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