UNLOCKING
CONSCIOUSNESS

BRIAN MIND FORUM

Appendix 018

Energy Generation in the Brian Mind

Understanding the power supply that drives the brain mind is a key element in understanding intelligence, let alone memory formation et al. The industrial revolution was built on our growing knowledge of steam and then electrical energy. The future direction of massive computer power may, equally, depend on our knowledge of neural power generation.

By contrast, computers receive all their energy from an external power supply, with sometimes just a very short term battery facility to cope with outages. All computer components use electricity, none can generate it.

Every neuron generates its own independent individual power supply. The nucleus of all neurons contains a parasitic organism – mitochondria - that pays rent for its home by converting nutrients supplied by the blood stream (the Nutrient Path) into the energy that the neuron uses to transmit patterns of electrochemical signals along its axons to activate muscles, glands and other neurons, and thereby organise and manage the whole body.

The immediate effect of this 'energy autonomy' is that neurons display many of the functions associated with living organisms. One important side effect of this is that neurons do not always respond as expected. Thus the reaction of a neuron is always 'probabilistic' rather than definable. This can have a significant effect on behaviour (If a computer component does not behave as expected it goes to an engineer to be mended).

Source of energy in the natural World

All energy derives directly or indirectly from the sun. There are two primary natural processes, photosynthesis and the processes associated with mitochondria and adenosine tri phosphate. Most people learn at school how photosynthesis in plants converts the sun's energy - heat and light into sugars – glucose and the like. Animals eat plants and convert the glucose into protein. Humans eat both plants and animals and convert the protein back into glucose. The cardiovascular system transports these nutrients to all the muscles, organs and crucially the brain mind (the nutrient path). Notwithstanding all the energy needed to move all our muscles – working, running, carrying heavy weights, battle et al, our relatively puny brain mind uses between a quarter and a third of all the fuel processed by our bodies. Astrocyte glia cells pass nutrients – glucose, oxygen and water from the blood stream to the nuclei of the neurons. First question: Is this an automatic function, or do we have some

neural control over what volume of nutrients flow to individual, or groups of neurons? Before addressing this question let us look more closely at how the Mitochondria operate. In many ways it is quiet extraordinary that this crucial function is in the hands of a parasite, that has its own quiet separate DNA.

Generating Neural Energy

In normal operation the Mitochondria convert glucose directly into sodium and calcium atoms to generate action potentials (electric current) to transmit 77 mille volt signals along its axons at about four feet per second. Axons, and dendrites are connected to other neurons, muscles, glands or other organs by means of synapses, or narrow gaps. These synaptic gaps, or clefts are held in place by the tension caused by the electrochemical activity of the signals being transmitted. When axon signals reach a synapse, they stimulate neurotransmitter molecules to travel from the axon pole across the synaptic gaps to stimulate activity on the opposite pole. These synaptic gaps, or clefts are held in place by the tension caused by the electrochemical activity of the signals being transmitted.

There are periods of maximum activity in, say, a crisis when a lot more energy is needed and periods when, say, during sleep very little energy is needed.

Also in the nucleus is a supply of Adenosine Di Phosphate (ADP). In periods of low activity, the mitochondria generate more energy than need so they add a phosphate ion creating Adenosine Tri Phosphate (ATP) – micro nuclear fusion.

In periods of high activity, the mitochondria can only generate part of the energy needed so they subtract a phosphate ion from Adenosine Tri Phosphate –micro nuclear fission. Thus ATP acts as a form of 'battery' to hold spare energy available in case of need.

Synaptic Tension.

Action potentials – electric current, pass along the axons usually to a synapse. If the amount of energy from both mitochondria and ATP begins to drop below a certain critical level the transmission signal begins to lose voltage, the tension across the synapse falls and the synaptic gap widens. This slows down the rate of transmission of signals across the synapses and does two jobs. This process acts as a circuit breaker to avoid overloading the circuits and doing damage. As the mechanism of sleep it enables the whole system to relax, sort itself out and enable the mitochondria to 'recharge' the ATP batteries to fight another day.

We can observe a similar effect with muscles and body organs in general. If nutrient levels are low then muscles lose tension, and flesh loses firmness. This is thought to be due to a shortage of water. However, it raises the possibility that water may play a role in neuron processing not previously suspected.

The possibility that axons and dendrites may vary in texture from firm to flaccid has not been researched. Similarly, not a great deal of work has been done on the whole nutrient path, from the gut, across the brain barrier, to the astrocytes to the neural nuclei. It seems highly likely that the quality, regularity and variety of food input must have a significant impact. Around half the children in the UK in 1910 were undernourished. Today about a quarter are overweight! We have a lot to learn. What is the effect on their intellectual capabilities?

Longitudinal surveys of the long term effects of the starvation of the Dutch by the Germans in the winter of 1944/5 show a marked effect not only on children, but also grandchildren of those unlucky enough to be involved.

Is it a co-incidence that the renaissance and the concurrent burst of intellectual activity occurred around the same time that sugar started to be imported into Europe? People are

generally attracted to food whose taste profile has been augmented by herbs and spices. The reason for the latter is usually considered to be edible longer before deteriorating. An alternative is that trace elements found in herbs and spices may well play a much more significant role that have realised especially in the immune system and the operation of the central nervous system.

Work at the University of California in 1993 showed that there is compelling evidence that aging and the rate of metabolism are directly linked. Research suggests that in periods of prolonged nutrient shortage the enzyme AMPK stimulates the breakdown of fat and stimulates the growth of new mitochondria (see note 1 below).

Dementia

There is another possibility regarding the onset of various forms of dementia. We all experience a loss of recall from time to time. We have the sensation we know an answer but cannot quite access it. It seems probable that the neural access algorithms successfully identify the correct information, but there is insufficient energy for that neuron, or more likely neuron network to penetrate conscious awareness. The brain gets increasingly full as the years pass thus the energy needed to learn new procedures and push their way into the mass of existing neural networks become ever more difficult. Thus we find it easier to recall something from the distant past than from last month.

Initiation of neural activity.

One of the conundrums of cognitive neuroscience is how we initiate activities? How is it that someone wakes up one morning and decides to learn French….? Or more prosaically decides to move jobs, or go to a film. If we are right that astrocyte glia cells regulate the passage of nutrients from the blood stream to the neuron nuclei, then the intriguing possibility arises that control of these glia cells would enable us to select which neural networks would have the larger supply of energy and therefore be more active. How could we test if we have neural, and conscious control over these astrocyte cells?

How have we evolved and inherited this complex energy generating system?

It is interesting to note that of the four base pairs of Nucleotides in DNA; Cytosine, Guanine, Thymine and Adenine, the latter plays a role very similar to Adenosine in the neural nuclei. Adenine can also extract energy by adding and subtracting phosphate ions, and in so doing powers the processes that convert one strand of DNA eventually into a fully grown person. Both Adenine and Adenosine are from the same family!

Note 1.

5' AMP-activated protein kinase or **AMPK** or **5' adenosine monophosphate-activated protein kinase** is an enzyme that plays a role in cellular energy homeostasis. It consists of three proteins (subunits) that together make a functional enzyme, conserved from yeast to humans. It is expressed in a number of tissues, including the liver, brain, and skeletal muscle. The net effect of AMPK activation is stimulation of hepatic fatty acid oxidation and ketogenesis, inhibition of cholesterol synthesis, lipogenesis, and triglyceride synthesis, inhibition of adipocyte lipolysis and lipogenesis, stimulation of skeletal muscle fatty acid oxidation and muscle glucose uptake, and modulation of insulin secretion by pancreatic beta-cells. [from wikipedia]