UNLOCKING
CONSCIOUSNESS

BRIAN MIND FORUM

Appendix 029

Neurogenesis
(References to Glia Bridges)

Growth of first neurons

The first neurons begin to grow in the foetus at about the third week linking the brain to the heart, stimulating the first heartbeat to start pumping nutrient rich blood to the brain. At birth babies have grown a large number of neurons with about half in the central nervous system and half concentrated in the brain. Growing neurons find their way by migrating along a 'scaffolding' of radial glia cells. Both glia cells and the growing neurons contain cell adhesion molecules (CAMs) which are attracted to various signalling (or trophic) molecules like nerve growth factors (NGF) in the central nervous system. The brain contains both brain derived neurotrophic factors (BDNF) and glial derived neurotrophic factors (GDNF).

The neuron nucleus acquires parasitic mitochondrial organisms that have their own DNA, which convert incoming nutrients from the blood stream into energy. The nucleus grows pairs of filaments linking the brain to every organ of the body. Axons transmit patterns of electrochemical signals to distant organs and dendrites transmit signals back to the nucleus. There are whole families of different neurons, but they mostly follow this pattern. However, many neurons have numerous dendrites and branches of dendrites, enabling the neuron nucleus to pick up as much information as possible; and often only one axon, although they can often branch close to their target.

Synapses

All neurons are connected to other neurons and organs by a complex linking system, known as a synapse, (see appendix 30), which consists of a narrow gap. The electrochemical signals transmitted along the axons and dendrites propagate fields of electromagnetic waves.

Energy

The mitochondria convert nutrients – sugars and oxygen – transported from the blood stream through astrocyte glia cells. If there is an excess of energy supply the mitochondria add ions to adenosine di phosphate (ADP) to create adenosine tri phosphate (ATP) to create a store of power – acting like a battery. When a burst of energy is required the mitochondria strip off the required number of ions. A miniscule atomic fusion and fission generator!

Brain mind, a learning machine

At birth we can do almost nothing, but we can learn to do almost anything. We can do little more than suck, yell, and swing our arms and legs about. We can hear noise and it is thought that some babies can begin to recognise their mother's sounds for some weeks before birth. We are all familiar with the remarkable way babies begin to learn to control their body functions, crawl, walk, run, and begin to learn to decode sounds and say words.

Learning language seems to be almost automatic. Babies try to group and recognise different sound patterns and then try and imitate saying them with endless repetition. The single network from the hearing organs in the ears fan out to the brain to reflect the different sound patterns. The networks linking the brain to the lungs, vocal chords, mouth, tongue and lips are similarly developed. Hearing distributes many connections to the brain from one source – the ears. Speaking concentrates many networks in the brain into one pattern of signals to activate the speech system.

We can observe that learning to read and write is significantly more difficult. The sight system of the eyes has to recognise the symbols of the alphabet and relate these shapes to the appropriate sounds we are familiar with. Instead of activating the speech system similar signal patterns have to manipulate the muscles in the hand and fingers to draw the appropriate symbols of the alphabet. The histories of languages and writing are fascinating, but there is much good literature on these subjects. We need only comment on the implications of the large number of 'words' that the human brain grows in a lifetime (see appendix 22).

Language is a good example to study as we are all familiar with it, however growing the networks to represent our entire range of knowledge and experience is an identical problem.

Information arriving in the brain mind arriving from all the sense and other organs stimulates glandular activity so that we feel the sensations of the emotions associated with that information. Chapter two describes in detail how information is represented in the brain mind.

Numbers of neurons in the brain

There is some doubt about the number of neurons in the brain. It is still very difficult to separate and count single neurons sufficiently accurately to estimate the total numbers. Similarly some observers quote the probable number of neural nuclei, other the number of neural networks, while other estimates are for the number of additional links.

Steven Rose, who has done as much experimental work on memory as anyone, argues in his book '*The Twenty First Century Brain*' that we are born with as many as 100 billion neurons. Suzana Herculano-Houzel writes in an article in Nature Neuroscience *'The Number of Neurons in a Human Brain'* that, by counting neuron nuclei, she estimates that a mature brain has some 60 billion neurons. Colin Blakemore calculates we grow between a thousand and a million new neural links or structures every second. Given that an average person lives for some 250 million seconds, that suggests we grow between 250 billion and 250 trillion new links and structures over a lifetime. Work at the Massachusetts Institute of Technology and the Karolinska Institute in Stockholm on mice have led to some calculations that may apply to humans. Jonas Frisen's research suggests that the human brain grows some 1,400 new 'cells', presumably neurons every day. [then mice do not have to cope with learning 100,000 words].

There is less knowledge about the neurons in the rest of the central nervous system. There is little or no evidence to suggest that any additional neurons are grown in the networks outside the brain.

There is considerable debate about whether neurons that are damaged or worn out are replaced. (see below).

A great deal of research has been done on how existing neurons and synapses are strengthened. Continuous use of the former, causes the neuron to be insulated (myelination) to make the transmission of information more efficient; while continuous use of individual synapses clearly strengthens them. Most cognitive neuroscientists argue this is how short term memories are strengthened – long term potentiation. Far less work has been done on how the very large number of new neurons are created. Logic suggests that new neurons represent new information which equals learning.

Processing new information

When a stimulus from a sensory, or other organ is received (as an electrochemical pulse travelling up a dendrite), it tries to trigger the path (by transmitting pulses across the network) of an earlier stimulus of the same experience. If it finds an existing path (a 'yes'), the neuron activates (and strengthens) the same response used by the earlier experience. If it doesn't (a 'no'), it triggers the growth of a new link (a 'conditional jump'), laying the new experience into the brain's memory stores. Eric Kandel won his Nobel Prize for demonstrating this basic learning process in the very primitive brain of the *Aplysia* which he describes in *'In search of Memory'.*

Growing new neural structures (learning).

How is this done? In '*Organization of Behaviour'* Donald Hebb coined the phrase "neurons that fire together wire together" growing new neural links and structures. (see appendix 10) The electrochemical activity along the dendrites and axons generates electromagnetic fields. Where two neurons are active together, these fields overlap and the combined magnetism is strong enough to attract free floating glia cells to grow a tentative link, or *Glia Bridge*. If this new 'circuit' is not reused or has no value it may dissolve. If it is frequently reused – is a valuable piece of information which we wish to retain - then the 'scaffolding' is in place for a new neuron to grow along this glia bridge *which would be a similar process to the growth of neurons before birth.*

Alternatively, active neurons further apart generate messenger molecules that carry out a similar task creating longer distance glia bridges.

Creation of memory

These new neural structures store the patterns of electrochemical activity which formed them, thus they can be said to be 'potential information', or a unit of memory. When these new links or structures are subsequently stimulated they reproduce the identical patterns of electrochemical activity which formed them in the first place. They can activate other neurons and organs and stimulate the same glandular activity so that we feel the sensations of the emotions associated with that information as we did when the original event occurred. This is now kinetic information and is doing work. Quite a respectable definition of 'memory'.

An adult 21st century brain is a massive relational database of billions of connections linking up related experiences. Very quickly, it has so much information stored in its neurons that some sort of hierarchy of focus develops to enable the organism to respond to imminent danger as fast as possible, while, at other times allowing the system to pause, reflect, evaluate and develop more efficient responses – grow and edit new networks.

The neuron nuclei initiate signals along their axons in response to stimulations from their dendrites. The operation of the synapses is reminiscent of transistors, but whereas a computer semi-conductor is 'digital' – it is either on or off, a synapse is 'analogue' – the signal transmitted is either strong or weak depending on the tension, and therefore the width of the synaptic gap. This fluctuating tension helps determine which neural networks have precedence and whether or not we are 'aware' of any particular neural activity. If the tension falls across the majority of the synapses we fall asleep.

Guy Claxton describes the brain as a 'shimmering mass of waves of electrochemical activity', even when we are asleep. Michael Levin at Tufts University, Massachusetts describes this background, or sleeping activity of the neurons as their 'resting potential'. If that activity ceases we are dead! A difference is that, whereas the reactions of digital computer circuits are predictable, the reactions of analogue neuron networks are 'probabilistic'. Nor only do all the nuclei have their own power generating system, and have many of the attributes of independent life. In addition the state of the synapses, hormones and other chemical stimulants triggered by signals from the brain, immune system and endocrine system also influence the inputs and outputs from the neurons. This is the complex 'hardware' system, which is the medium over which the background operating system of the whole body, the underlying, or 'autonomic' 'software' system of electrochemical signals are transmitted coordinating and synchronising the whole organism to work together in harmony.

The Efficient organisation of information in the brain mind

This is where language makes a massive contribution in addition to providing a means of communication. In the process of learning one hundred thousand words or more, plus all their meanings and combinations, language provides an indexing system. *We invent words to 'label' complex new ideas*. Thus we can discuss new abstract concepts (stimulating massive neural structures in the brain minds of the hearers to match the massive neural structures in brain minds of the speaker) much as the programmer uses a computer language to design new applications. Both employ similar logical processors to solve problems. Donald Hebb called these neural structures '*engrams'*. We prefer neural modules, or '*neurules*'. Richard Dawkins promotes '*memes*'. Programmers call them *'subroutines'*. See appendix 12

It is important to recall that the brain mind has no processor, or more accurately the brain mind is its own processor, driven entirely by incoming information. The brain mind grows a neural response to all information it receives, whether strengthening an existing 'trace', or generating a new one. By always building on existing traces a mass of cross references and relationships develops, which contributes to the meaning of information received. We store a minimalist neural record of every visual image we see for at least twenty seconds. See appendix 28.

Simplifying complexity: basis of Thinking.

By labelling groups of neurons with one word, then linking that word with others and labelling them we construct a hierarchy of concepts that facilitate the process of 'thinking'. See chapter four. Thus the brain mind continues to evolve by meeting ever greater complexity with ever greater simplicity.

Replacement of Neurons

There is much debate over whether worn or damaged neurons are replaced. There was a phase some years ago when journalists used to enjoy scaring people but saying how many of their neurons had died while they were reading their articles. This was later comprehensively disproved by a number of studies. It does leave an interesting question. The thrust of present think is fairly confident that the billions of neural links and structures we grow in our lifetimes are extensions and expansions of the basic 'framework' with which we are born.

Thus most, if not all mature neurons will be very different from the neurons generated by the DNA at birth. All other cells in the body remain the same. If a fingertip is damaged replacement skin cells are generated by the copies of the original DNA and the original fingerprint is reproduced.

Is the replacement neuron a copy of the neuron at birth, or a copy of the neuron which may include many new axons and dendrites, which, in turn have many new synaptic links to other neurons and organs, muscles and glands?

The later seems more likely, otherwise all learning which involved that neuron would be lost. However, if the former is true then the next question is “where are these amendments and additions stored?” Logic suggests that all amendments must be stored somewhere other than in the dead neuron. Could it be that when new neuron links and structures are grown the DNA in the host neuron is edited to include these changes, and is stored outside the nucleus? Could edited DNA find its way into semen? And if that is the case then that provides us with a basis for Lamarck’s ‘*transgenerational epigenetic inheritance’*.

And there is already some evidence to support this radical conjecture. Arturas Petronis at the Centre for Addiction and Mental Health in Toronto, Canada, reports finding distinctive epigenetic marks in some of his patient’s genes. These marks are indicators that gene expression has been altered, and Professor Petronis reports finding them not only in the frontal cortex of his patients, but also in their sperm. [American Journal of Human Genetics vol 82 p 696]. In another field of research, Marcus Pembrey of the Institute of Child Health at UCL suggests “some sort of key information – perhaps epigenetic in nature – is being captured at the stage of sperm and egg formation, then passed down generations” [European Journal of Human Genetics vol 14 p 159]

Summary

Thus we can begin to see a clear path for how incoming information from, say, the ears and eyes can cause new patterns of neural networks to grow, creating new memory structures: how these new structures are integrated into the general structure of the brain mind, building networks of relationships and cross references, giving this new information depth and meaning.

We can also begin to see how evolutionary modifications might be passed on to successive generations.

2018 // Book Final // Appendices NEW // 029 Glia Bridges Neurogenesis