Neuroscience and Wellbeing

Taken from: *'A Well Gardened Mind – rediscovering nature in the modern world'* by Sue Stuart – Smith + *The Brain* by David Eagleman

Brain Facts

The BRAIN is the most complex organ we know. It is the organ of relationship.

- It weighs 3lb and has 85 billion neurons and 10,000 connections.
- In just 1 cm3 of brain tissue there are as many connections as star in the Milky Way.
- It uses 15-25% of our body energy despite only being 5% of our body weight
- We are the only species to try to decipher and understand how our brains function
- It functions almost entirely under conscious awareness – for example picking up a coffee, driving a car, falling in love
- Decisions we make consciously have been mulling in the subconscious for some time – using the metaphor of a mansion house - the conscious mind is the broom cupboard with the all the rest of the rooms in that mansion representing the unconscious mind – the mulling allows the creative subconscious to work to help make decisions using 'gut instinct' as well as the more conscious logical problem solving.
- It's the neurochemistry of our brain that drives our emotions and behaviours

It is a wet amorphous grey alien looking mass –it is the densest representation of YOU – all your hopes and dreams, decisions, risks capacity of possible futures.

We can reflect on the past and imagine the future which no other mammals, as far as we know, can do.

It's what makes us see colour, hear music., smell flowers, taste fresh strawberries, feel the touch of someone's hand, create art and music and fly around the world and to the moon it helps us imagine other worlds and places.

The tickly side of it is that we can also ruminate on the past and catastrophise about the future – which leads us to feel stressed in the present.

"In each of us there is another we do not know" Jung

“There is somebody in my head but it’s not me” Pink Floyd

In nature away from the human voice and construction we can connect with our ancient self.

The idea that we can ‘cultivate’ the soul or the self like a ‘garden’ goes back to ancient times and is beginning to be applied to the brain in contemporary science as a metaphor. The cells that create our neural networks grow in the form of tree-like branching structures and were originally named dendrites after the Latin word for tree because of their visual similarity to one. This resemblance, it has recently been discovered, reflects the fact that neuronal arbours and plants grow according to the operation of the same three mathematical laws as our own neurones.

At the very beginning of life, the brain is a tangled wilderness of more than 500 billion neurons. In order to develop into a mature brain, 80 per cent of these cells need to be cleared away to provide space for the remaining cells to create connections and establish complex networks.

We can see the garden metaphor and its maintenance being extended to the active process of “pruning” and “weeding” that maintains the health of our neural networks and is carried out by a group of cells which function as the brain’s resident gardeners. These cells are known as microglial cells.

This process gives rise to the unique pattern of connectivity that makes us who we are. The brain grows in early life according to how it is nurtured, through the love, care and attention a baby receives.

As the brain’s neurons fire in response to experience and the links between neighbouring neurons are either strengthened or weakened depending on the amount of use. These points of connection, known as synapses, involve a tiny gap across which the brain chemicals known as neurotransmitters travel in order to connect with receptors on the other side.

Over time, synapses that are not being used are pruned away so that the ones in regular use become better established and have room to grow.

What fires together wires together.
The neural networks in our brains are shaped and reworked throughout the entire life cycle. The ability of neuronal connections to change like this is known as neuroplasticity, a term that derives from the Greek plassein, meaning to shape or mould.

When the neuroplasticity phenomenon was first identified in the 1950s no one had any idea how the shaping of the brain’s networks came about and it remained a mystery until the role of the microglial cells was eventually revealed. These cells, our resident gardeners are part of the immune system, account for one in ten cells in the brain.

It used to be thought that they were passive unless activated by infection or injury but it is now known that they appear in the embryo only a few days after conception and are involved in how the brain grows and repairs itself from the very beginning.

These specialist cells are highly mobile and as they crawl in amongst our neural networks, they weed and root out weak connections and damaged cells. Most of this activity happens while we sleep, when the brain shrinks and gives the microglia room to go about their work using their finger-like projections to remove toxins, reduce inflammation, and prune redundant synapses and cells.

Recent developments in imaging techniques have made it possible to observe them in action and it appears that each one tends its own patch of neural territory. Like true gardeners, they not only weed and clear, they also help the brain's neurons and synapses to grow.
This process, known as neurogenesis, is facilitated by a protein that they and other brain cells release, called brain-derived neurotrophic factor, or BDNF.
The effects of this on neuronal cells is akin to that of a fertiliser, which has earned it a reputation as the brain's 'Miracle-Gro'.

Low levels of BDNF lead to depleted neural networks and are increasingly thought to be implicated in depression.

BDNF levels can be boosted through various forms of stimulation, that include exercise, play and social interaction. A constant process of being weeded, pruned and fertilised keeps the brain healthy at a cellular level.

The activity of the microglia exemplifies one of the fundamental laws that govern life – that health is not a passive process. What is taking place on a microscopic scale also needs to happen on a larger canvas. The mind needs to be gardened, too.

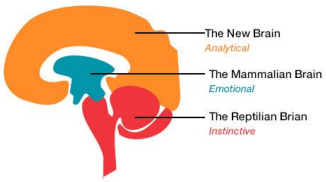
Our emotional lives are complex and need constant tending and reworking. The form this takes will be different for each one of us but fundamentally, in order to counteract negative and self-destructive forces, we need to cultivate a caring and creative attitude toward ourselves. Above all, we need to recognise what nourishes us.

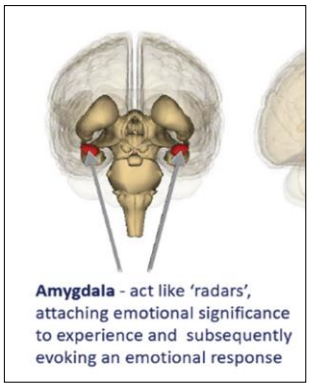
We are a grassland species that emerged in the savannah landscapes of Africa and, over the course of evolution, our nervous systems and immune systems have been primed to function best in response to various aspects of the natural world. This includes how much sunlight we get, the kind of microbes we are exposed to, the amount of green vegetation around us and the type of exercise we take.

We live with our evolutionary past, or rather it lives through us.

In terms of the brain, nothing has been lost over the course of evolution and its structure is, as the neuroscientist Jaak Panksepp described it, a ‘nested hierarchy’. The brain’s layers are folded on top of each other with the higher cortical parts enclosing the more ancient mammalian and reptilian structures.

Our brains are wired for survival – in the oldest part the reptilian brain the vital physical centres are found – heart centre respiratory centre temperature regulation – literally keeping us alive. As reptiles evolved into amphibians they moved out of the water onto land – a more hostile environment and as mammals evolved they gave birth to live young that needed to be nurtured over long periods of time. So the mammalian brain developed that was all about emotional attachment to children family and social group. The amygdala and hippocampus sit in this part if the brain. The hippocampus is where memory sits and the amygdala is the brains ‘guardhouse’ – it is the part of the brain that scans the horizon looking for threat. It is triggered by threat to give an emotional response of freeze fight or flight. In our evolutionary past physical threat was from predators – now for most of us we don’t experience physical threat on a regular basis unless sin a war zone or any other violent environment. However, because our brains still function in the same way i.e. looking for threat – we now look for and see psychosocial threat – Does that person like me? What did the team think of my presentation? Is my job safe? Was that the right decision?





These different structures communicate through a myriad of neural networks enabling us to integrate memories, sensations, thoughts and feelings. Under normal circumstances the brain is a wonder of connectivity, but if triggered to a fight or flight mode by the amygdala

we have a strong emotional response - Fear Anger Disgust Shame and Sadness. These emotions are associated with the release of cortisol.

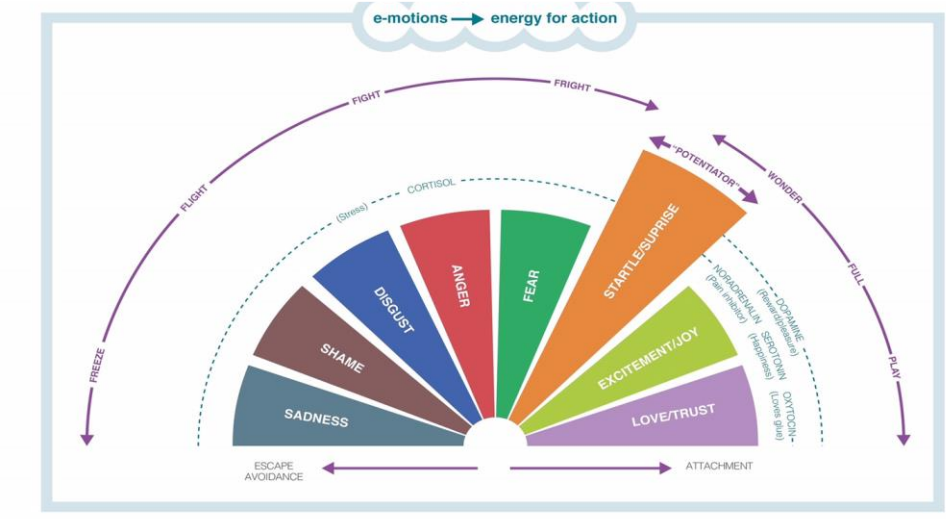
Cortisol is useful in short term bursts. Small increases in Cortisol can have a positive effect and can create:

- Quick burst of energy for survival reasons
- Heightened memory function
- A first of increased community
- Lower sensitivity to pain
- Help in maintaining the balance of all the functions of the body.

Think a bit like a small tap on the accelerator to get around the tricky bend rather than keeping your foot down all the time and flooding the system and burning out the engine.

However, Cortisol is often described as a corrosive chemical as under some conditions it can actually kill off neurons. Prolonged and unnecessarily high levels of cortisol in the bloodstream have been shown to be associated with adverse effects such as:

- Impaired cognitive performance
- Suppressed thyroid function
- Blood sugar imbalances
- Decreased bone density
- Decrease in muscle tissue
- Raised blood pressure
- Lowered immunity and impaired inflammatory response is such as slower wound healing
- Increased abdominal fat
- Higher levels of bad cholesterol.



Bringing our emotions over to the right hands side of this model to the trust love joy and excitement means we establish a sense of trust and safety so that we are able to let our defences down and think and act in more creative and positive ways.

The other things at play here is the environment in which our brains function

In terms of evolutionary time environmental scientist Jules Pretty has calculated that for 350,000 generations, people lived in close proximity to nature and that our brains evolved and developed in response to that environment – in contrast Jules Pretty calculated only 6 generations of people have been inhabiting large, densely built up cities.
'Put human history into one week, starting Monday,' he writes, 'and this modern world emerges about three seconds before midnight on the Sunday.'

Many of the negative effects of city living stem from a fundamental mismatch: the human brain evolved in the context of the natural world, yet we expect it to function optimally in the unnatural urban surroundings that people inhabit today.

States of relaxed and immersive attention helped our remote ancestors survive in the wild. Successful hunting and gathering depends on this kind of attention and in being relatively effortless it can be sustained for long periods of time.

By contrast, contemporary lifestyles rely more heavily on a narrow, focused form of attention. The significance of the two different kinds of attention was demonstrated in a series of experiments starting in the 1980s, by the psychologists Rachel and Stephen Kaplan.

Their influential theory of Attention Restoration

This is based on their finding that natural settings are a highly effective way of giving our task-focused thinking a rest and restoring our mental energy. When we overuse our conscious cognitive processing skills, we are susceptible to what they called 'attention fatigue' and the brain becomes less able to inhibit distracting stimuli. There are many studies that demonstrate this effect. One, for example, found that students who walked 45 minutes in an arboretum performed 20 per cent better in subsequent tests than a similar group who walked along busy urban streets.

As Olmsted described, contact with nature can have the effect of simultaneously calming and enlivening us. Attention is, however, more than a cognitive function. The psychiatrist Iain McGilchrist argues that we make an error if we limit our understanding in this way, because attention is, as he puts it, 'the main medium by which we enact our relationship with the world'. Having spent the last twenty years researching the relationship between the right and left hemispheres of the brain, McGilchrist has concluded that they specialise in different forms of attention.

The left hemisphere gives rise to a narrow, focused attention, while the right hemisphere's functioning is characterised by a broad and open attention to our surroundings. This same hemispheric specialisation for processing incoming information is found in other animals and is thought to have evolved because it was necessary for survival. Animals and birds

need to direct their attention on catching and killing their prey whilst simultaneously staying alert to the wider terrain. This model is necessarily simplistic when applied to the human brain which is complex and highly integrated. McGilchrist acknowledges that our hemispheres communicate all the time and contribute to everything we do.

However, we can overuse certain processing skills and neglect others so that we feel disconnected from our feelings, our surroundings and other people. As he explains, the nature of contemporary life, with its screens and computers, means we are dependent on the left hemisphere's mode of attention processing about 80 per cent of the time. He believes that this imbalance is linked to the rise of anxiety and depression, as well as contributing to more generalised feelings of emptiness and mistrust.

This is because the left hemisphere prioritises everything functional and specialises in categorising experience. Its focus on 'getting' and 'using' and does not bring much meaning or depth to life. The right hemisphere, in contrast, specialises in connection rather than categorisation. It brings us the richness of the world through being better connected to the body and the senses. Our capacity for empathy and our deepest humanity comes to us through the right hemisphere as well as our feelings of connection to nature. According to McGilchrist, the right hemisphere puts us in touch with the freshness and vitality of the world.

To feel a sense of emotional connection with other forms of life and be in touch with their vitality is linked to what the eminent Harvard biologist E. O. Wilson called biophilia. He put forward the idea that there is an innate 'emotional affiliation of human beings to other living organisms'. Since he first proposed his biophilia hypothesis in 1984, biophilia has become a buzz word within environmental psychology. Wilson's hypothesis is based on the fact that the natural world was the main influence on the evolution of our cognitive and emotional functioning. People who were most attuned to nature, and most predisposed to learn about plants and animals, would have survived better. Because we no longer commune with the natural world on a daily basis, we do not develop the same level of attunement, but still it lies latent in all of us.

Loss of motivation is a common mental health symptom. The neurotransmitter dopamine is one of the basic chemicals of life and we share it with other mammals. Dopamine triggers the kinds of exploratory or seeking behaviours needed for survival and plays a crucial role in the brain's 'reward' system – which is in fact more like a seeking system because it is driven by the anticipation of a reward more than the reward itself. It gave our hunter-gatherer ancestors the 'get up and go' to explore their surrounding terrain: if they had waited till they were hungry they would have lacked energy to traverse the ground and collect food. As a result, the brain evolved to reward us for learning about our environment. Most of our dopamine arises from two tiny clumps of cells deep within the ancient layers of the brain; long nerve fibres convey it to the farther-flung reaches, including the cortex, which means that in humans the urge to explore that it engenders is intellectual as well as physical. Dopamine generates a sense of purpose and a state of optimistic expectation and it boosts connectivity and communication throughout the brain so that if our dopamine levels are low, we feel that we have lost our 'mojo'.

Decades of research on laboratory rats – whose neural systems bear similarity to our own – have shown that when they are raised in what neuroscientists call enriched environments, they are healthier, more resilient to stress and better at learning than rats which have not been. Their brains show evidence of increased neurogenesis and raised levels of BDNF with twice as many neurons in the dentate gyrus of the hippocampus, which plays a critical role in learning and memory.

An enriched environment cage typically contains a wheel, a ball, a tunnel, a ladder and a small pool – the rat equivalent of a playground. The different forms of stimulation within it trigger seeking and exploring activity. The comparison rats are reared in standard cages containing only food and water. Laboratory work on the effects of environmental enrichment on the brain has until recently had nothing to do with natural forms of enrichment.

That situation changed when Kelly Lambert, Professor of Behavioural Science at the University of Richmond, Virginia, decided to include a third type of cage; one that contained soil and plant material, including sticks, stumps and a hollowed-out log. Rats are nocturnal, so their behaviour was monitored under a form of red light that is not detected by them. When Lambert looked at the footage the next day, as predicted, the rats in the standard, relatively empty, cages were, in her words, 'behaving like zombies' – barely interacting with each other. The rats in the artificially enriched cages were more active and sociable.

But when she looked at the rats in the naturally enriched cages she could not quite believe what she was seeing. She was so surprised that she called over her assistant to watch with her. For generations back, none of these lab-bred rats had been anywhere near nature, so they might have been expected to prefer plastic toys to sticks and dirt. But surrounded by the little bit of nature in their cages, they were the most excited and active lab rats the research team had ever seen. They were playing and digging and clearly enjoying themselves. More than that, they were connecting and interacting with one another in a much more sociable way. The findings were so striking that Lambert and her team ran a second set of experiments, this time for a longer period of sixteen weeks; again, the 'city rats' and the 'country rats', as Lambert by then was calling them, were compared to each other, as well as to the rats reared in standard cages. The results of the biochemistry tests on the city and country rats were largely similar with both being superior to the unstimulated rats, although the ratio of the hormone DHEA to corticosterone was healthier in the 'country rats'.

But it was when it came to the analysis of their behavioural patterns that the 'country rats' definitely had the edge. Compared to the 'city rats', they were more resilient when they were exposed to stress, they explored for longer and showed more persistence in tests, and they were more sociable with other rats. Although Lambert calls them 'city rats' and 'country rats', what she gave her country rats was not countryside – that would have involved setting them free – it was more like giving them a garden to play in. What is amazing about this is that in all the decades of research on enriched environments, the difference between natural and artificial stimuli had been so little investigated. It seems that contact with natural elements stimulates the nervous system in a more powerful way than

artificial elements can. The rats certainly recognised the difference; they were demonstrating the rat equivalent of biophilia.

Common sense suggests that fresh air, daylight, exercise and access to green, quiet places are going to be good for people's health in cities. We have, though, reached such a point of remove from these elements that we need scientific evidence to demonstrate their effects to us. There is, however, one benefit of green space that common sense might not predict so well which is its 'pro-social' effect. Lambert discovered this in her experiments when the 'country rats' groomed each other and interacted with each other in a more sociable way. Frances Kuo and William Sullivan observed it in Chicago housing studies that showed a strengthening of social networks. In terms of city living, this may be one of nature's most profound effects on us. Put simply, people behave better and connect with one another more when they are in the presence of plants and trees. The sociability effect of green vegetation on people has been demonstrated in laboratory research. For example, one study found that being in the presence of indoor plants or looking at scenes of nature, as opposed to urban scenes, prompted people to make decisions that showed higher levels of generosity and trust.

The more immersed people were in the natural scenery, the stronger the effect. A different study carried out in Korea using fMRI brain scans found that pleasing natural scenery activated the parts of the brain involved in generating empathy. The team followed the scans with psychological tests which showed an increase in generosity as well. These experiments suggest that we become more trusting and giving when we feel enriched by nature.

The presence of nature, on the other hand, helps us to feel more connected to the world around us. Rather like putting on a different pair of spectacles, we see the world slightly differently, and it is not confined to the trees and the greenery; we see people differently too. Trees, parks and gardens work on us imperceptibly, softening our gaze. Everyone shifts a little bit closer towards empathy and human connection.

Zeki has conducted experiments on beauty. Looking at music art works and mathematical equations. His participants were given a range of visual images, music and equations to respond to. The experiences they found beautiful all produced the same pattern of activity within the medial orbitofrontal cortex, the anterior cingulate cortex and the caudate nucleus – brain regions that are part of our pleasure and reward pathways and are also associated with romantic love.

These pathways also play a role in integrating our thoughts, feelings and motivations. They are associated with our dopamine, serotonin and endogenous opioid systems and damp down our fear and stress responses.

Hence, beauty calms and revitalises us at the same time. The human aesthetic response includes an affinity for patterns in which regularity and order are combined with variation and repetition. The simple geometries we find in nature are perhaps at their most concentrated and compelling in the beauty of a flower's form. Wildflowers, for example, commonly have five petals arranged in pentagonal symmetry. But no matter how elaborate

or simple, the structure of any flower displays proportion, balance and harmony and we respond to this much as we respond to rhythm and harmony in music. This reaction may be linked to Zeki's findings on mathematical beauty, for in the evolution of human culture, botanical patterning must surely have played a part in awakening the human mind to the possibilities of abstract beauty and mathematical form.

The chemical constituents of various floral scents prime our moods and influence how alert or relaxed we feel. Lavender, long known to have a calming effect on us, has recently been shown to raise levels of serotonin. In contrast, the smell of rosemary is stimulating and boosts levels of both dopamine and acetylcholine. Citrus blossoms are uplifting through the combined effects of serotonin and dopamine. The smell of roses, perhaps the scent we most strongly associate with love, is good at reducing levels of the stress hormone adrenalin, in one study by as much as 30 per cent. In addition, through the action of the compound phenylethylamine, the fragrance of the rose reduces the breakdown of our endogenous opioids creating a feeling of lingering calm.

The human species evolved to be good at forming relationships. We are so good at them that the brain has been called a 'relational organ'. The botanical world also evolved to be good at forming relationships, so it's not surprising that in the course of our prehistory we formed such a strong affiliation with plants and flowers.

Jung wrote 'Aren't we the carriers of the entire history of mankind? When a man is fifty years old, only one part of his being has existed for half a century. The other part, which also lives in his psyche, may be millions of years old … Contemporary man is but the latest ripe fruit on the tree of the human race.' We need to reconnect with what he called 'the dark maternal, earthy ground of our being', but in seeking to control nature, we have isolated ourselves from her and robbed ourselves of our natural history.

He believed that 'every human should have a plot of land in which to walk or work so that their instincts can come to life again'. To be in touch with the aliveness of the natural world is deep in our psychological ancestry.