

# Nervous Systems, Nerves and More...

*It has to be emphasised that what follows are theories. Thanks to discussions and debates, theories change! So what I write here may be useful in five years...or maybe not. Understanding our nervous systems is useful for us as practitioners and teachers because this can guide us toward calmer and healthier well-being. These insights help us to understand how our bodies work and so make our practising more beneficial.*

*An image that might be useful here is climbing a high mountain. We have to start at the bottom. We could feel overwhelmed by the sheer size of this mountain. Baffled and bewildered by its complexity. The vast number of potential paths. Perhaps there is dense cloud cover and thick forests. We are almost paralysed by the range of possibilities. And then slowly, slowly, with small steps, things begin to make some sense. Steps of minimising of myths, letting go of simplistic rhymes, encouraging of clarity. Some of the ideas in this article are straightforward. Some are more technical and complex.*

*It has taken me many years to begin to have an understanding of the nervous systems and their varied connections. Within our bodies, there is an overall nervous system made of central and peripheral systems as well as other elements discussed below (thus this using of the plural: 'nervous systems'). Study of the nervous systems reveals a minefield of different opinions and ongoing disputes; like is the vagus nerve more important than the phrenic nerve – or vice-versa? Or both, as both are essential to our body functioning and our wellbeing. Mistakes are made. Sometimes innovative theories are revealed to be like the emperor's new clothes: on closer inspection and with sustained study, not all that they originally seemed to be. And sometimes innovative theories stand the test of time and examination.*

*Highlighting particular anatomical structures can certainly be insightful and an accessible way in. This can also be problematic, as sometimes such focusing becomes obsessional and even commercially-driven. Then the role of what is emphasised (the heart, the vagus nerve, the hips) could be exaggerated and hierarchical. One practitioner told me: "We don't need more hierarchies."*

*It is good to approach this vast subject with curiosity, openness and wonder as the pathways often change...*

## SYSTEMS

A system is a set of things working together to achieve a common goal. The goal for the nervous system is for us to survive: 'in service of survival'. For this to happen, we need to feel safe (feelings of safety help us to feel safer). This safety is about our bodies, our environments and our relationships with others.

The nervous system could be described as 'the body's electrical wiring', its collection of nerves and cells transmitting signals throughout the body. It is a communication network for the body and has been called "the most complex product of biological evolution".<sup>1</sup> The nervous system can be divided into the central and the peripheral branches. The central branch is in the brain and the spinal cord; the peripheral branch is the "cranial, spinal and peripheral nerves, together with their motor and sensory endings".<sup>2</sup>

This article is about the autonomic nervous system (ANS); the ANS is found in both the central and the peripheral branches. It comprises the sympathetic nervous system, the parasympathetic nervous system and the enteric nervous system. The ANS could be described as our personal surveillance system.

The sympathetic part of the ANS might be described as being more active while the parasympathetic part of the ANS might be described as promoting maintenance of the body at rest. The enteric nervous system governs the functioning of the gut area and has sometimes been called 'the belly brain'. It is important to emphasise that this is significantly simplifying considerable complexity!

## WHAT IS IMPORTANT...

What is important is that we are looking for a balanced ANS, not an approach that emphasises the parasympathetic over the sympathetic nervous system — or vice versa. We must not demonise the sympathetic nervous system through misunderstandings and misinformation. It is incorrect to revere the parasympathetic nervous system and to be dismissive of the sympathetic nervous system — and this is something that has been common in some yoga circles. I hold my hand up here. Until recently, I have held and publicised this view, such as in my book *Brightening Our Inner Skies* (p79) and in classes and on trainings.

Unquestionably, we need *both* the sympathetic and the parasympathetic nervous systems. They work together to regulate the body. We are attempting to be balanced, even if sometimes not that successfully. When we are more balanced, perhaps we can see more clearly and thus act more appropriately.

This balance might be imagined as being on a see-saw between sympathetic activation and parasympathetic activation. Too much of either is not beneficial for our functioning. As Charlotte Watts wrote in *Yoga Therapy for Digestive Health*: “Finding equilibrium between stimulation and regular rest balances these systems and strengthens the ability to manage stress.”<sup>3</sup>

Rather than separate compartments and divisions (and overemphasis on particular parts rather than acknowledging the overall systemic connection), health is about homeostasis. “[It is] the ability to maintain a relatively stable internal state that persists despite changes in the world outside... All living organisms, from plants to puppies to people, must regulate their internal environment to process energy and ultimately survive.”<sup>4</sup> But though the body as a living organism aspires for homeostasis, sometimes our behavioural patterns might mean what we experience as ‘balance’ actually is damaging our health. An example of this is addiction to substances or activities that negatively impact the body.

## CONSTANTLY EVALUATING

The ANS constantly evaluates the environment (inside the body and out). This happens far below our general awareness and far away from our conscious control and is asking these kinds of questions.

- Is there safety?
- Is there danger?
- Is there life threat?
- Is there balance (as body systems look to maintain equilibrium)?

We can identify three primary functions of the ANS.

- social engagement
- mobilisation
- immobilisation

The sympathetic part of the ANS is more about mobilisation. In fact, without the sympathetic nervous system, it is impossible to move. Without it, it is also impossible to breathe (unless you are on an intensive care breathing machine). So without the sympathetic nervous system, we would be dead. Fibres of the sympathetic nervous system are found throughout the entire body; the only parts of the body without these fibres are structures such as nails and cartilage (avascular (having little or no blood vessels) structures). Functions of the sympathetic nervous system include pupil dilation, goose bumps, sweating, increasing heart rate, release of adrenalin and much more.

Each in-breath could be said to be the sympathetic nervous system, each out-breath could be said to be the parasympathetic nervous system. The right hemisphere of the brain could be said to associate to some extent with the sympathetic nervous system; the left hemisphere to some extent with the parasympathetic nervous system.<sup>5</sup> However, studies showing this have been few. According to one

article: “This lateralisation framework remains controversial due to the inconsistencies in the human lesion literature.”<sup>6</sup>

## **OTHER STATES**

Other states of the ANS could be described as:

- Play (this is the sympathetic nervous system plus safety)
- Intimacy (this is the parasympathetic nervous system plus safety)
- Appease/befriend (this can be related to the ‘freeze’ response and is about trying to calm down an aggressor; often it can be seen amongst trauma survivors)

When there is threat, we can go into the state of ‘freeze’. This freeze state is the most extreme defence strategy available and is only used as a last resort. Another name for this freeze strategy is ‘feigned death’. This is a function of the parasympathetic nervous system.

If parasympathetic encouragement is excessively stimulated through, for example, long exhales, then this can take a person towards dizziness, nausea, fatigue, depression and fainting. All of these can be features of excessive parasympathetic dominance. One cause is practicing unbalanced breathing patterns. These kind of side-effects are not necessarily what we are looking to do in the name of yoga!

## **HOME SECURITY SYSTEMS**

If stress levels are very high, this can trigger hypervigilance, with a person constantly on guard and looking out for danger. They can misperceive situations, feel disconnected, fear intimacy. Such states are deeply exhausting and the person can experience anger, frustration and depression. High levels of stress may be a symptom of Post-Traumatic Stress Disorder (PTSD). PTSD can occur when a person’s survival feels threatened for any number of reasons. It could be said that a person with PTSD is not able to maintain balance between parasympathetic and the sympathetic nervous systems.

Our in-built ‘home security system’ (or sympathetic nervous system) gives us both the ability to move and is ready to react to any emergencies (‘threats’). When threat is perceived, the sympathetic nervous system can equip and enable the body to deal with it, suppressing unnecessary bodily functions (like the immune system, digestive system, even cognitive thinking – as thinking our way out of danger can be very slow) and engaging the needed elements to deal with the situation (like increased blood flow to muscles and stimulation of cortisol (a hormone produced by the adrenal glands that helps the regulating of many body processes) and noradrenaline (a neurotransmitter of the sympathetic nerves that can increase heart rate and influence motivation)).

When threat is experienced, long-term health is not a priority; what *is* essential is short-term survival. When threat is immediate, there is not time for detailed body debates. Heart rate increases, breathing becomes faster to pump more oxygen around the body as this is the body’s fuel, the amygdala (which is the seat of emotions and emotional memories in the brain) becomes more stimulated, pupils dilate so that vision is more alert.

Again, this substantially simplifies some highly complicated relationships and reactions. For example, the immune system can also be activated by the sympathetic nervous system; this means that the sympathetic nervous system is able to both suppress and activate the immune system.

If the sympathetic nervous system is more active than is actually needed because of factors such as excessive sensory stimulation, there can be difficulties (for example, feeling overwhelmed and highly stressed). Every time one of our devices buzzes or pings or clicks or vibrates, the nervous system responds as though it needs to do something (so being on increased alert). We might think that we are not reacting to electronic stimulation but in reality, the body and the nervous system tell a different story. This is why it can be good to turn off notifications!

A theory is that we are not evolving at the pace at which technology has evolved. Our nervous systems are not designed to cope with the high levels of stimulation present for so many of us in today's world. Our brains are not fast enough to interpret the barrage of information that is being sent to them. The amount of stimulation that our bodies/nervous systems/brain receives has hugely increased in the last 100 years, in the last 50 years and even in the last 10 years. The reality is that much of our surroundings is sympathetic nervous system dominant – and consequently, society does not promote sufficient resting.

When the sympathetic nervous system is particularly dominant, the world can feel dangerous and unfriendly. This can mean that we are more depleted and overwhelmed, more defensive and exhausted. Over-activation of the sympathetic nervous system can lead to a person 'crashing' and then possibly becoming dominated by their parasympathetic nervous system. Chronic over-stimulation of the sympathetic nervous system is potentially damaging to our bodies as much as chronic over-stimulation of the parasympathetic nervous system is potentially damaging to our bodies (which could manifest as low motivation and/or depression). This is about being balanced on that see-saw.

It is constructive to question the popular theory that many people are being overwhelmed by sympathetic arousal. One example is that a few depressed people do not have high levels of cortisol (high levels of cortisol can indicate sympathetic arousal); so possibly they could be more in parasympathetic dominance.<sup>7</sup> If a person's resting heart rate is below 100bpm, in medical terms they could be perceived as being in parasympathetic dominance.<sup>8</sup> As much as some people need slowing down, some people need firing up and being more activated.

## **DIFFERENT BODY SYSTEMS**

There are incredibly complex inter-relatings between different body systems and different body processes. How well these inter-relationships between systems function may explain physical and psychological disorders. One example is dysautonomia, a condition in which the ANS is not working properly. Symptoms can include blood pressure issues, memory loss and anxiety.

By beginning to understand the ANS, we can appreciate all that it is doing for us. We can also be mapping and tracking its processes through attending practices such as meditation, psychotherapy, yoga and more. This can then allow us to intentionally and appropriately tune the ANS. This tuning is looking for a balanced ANS. Simply, what brings us closer to safety and connection?

There are numerous ways to improve the functioning of these systems' relationships: going for walks in nature, good sleeping patterns, coherent breathing, movement practices, meditation, healthy diets, social connections, getting supported from experienced health care practitioners – and much more. Robert Putnam, a political scientist and public policy professor, wrote: "The single most common finding from half a century's research on the correlates of life satisfaction, not only in the United States but around the world, is that happiness is best predicted by the breadth and depth of one's social connections."<sup>9</sup>

Neither health nor wealth but "one's social connections". A valid question that can be asked is how much is the community component of yoga classes positively influencing our bodies, such as the nervous systems and the immune system?<sup>10</sup> Important to remember this amongst more technical discussions! Another description is by Judith Herman, a psychiatrist who focuses on traumatic stress. "Recovery can take place only within the context of relationships; it cannot occur in isolation."<sup>11</sup>

In this culture of extreme levels of sensory stimulation and extreme levels of individualisation, we can forget that human beings are essentially social animals. We need a herd in order to survive.

## **THE OLFATORY NERVE, THE PHRENIC NERVE AND THE VAGUS NERVE**

The speed and the different pathways with which our bodies talk to themselves is remarkable. Scientists first identified neurotransmitters in 1926; now more than 100 substances have been identified as playing a role in signal transmission between nerves. Nerve impulses travel at speeds of

up to 100 metres per second. In comparison, the fastest flow of blood in the body (in the aorta) is 30cm per second (more than 300 times slower than nerve impulses); and elsewhere in the body it is significantly slower.

Three nerve pathways that are very important to our functioning and everyday living are the olfactory nerve (*olfactus* being Latin for to get the smell of), the phrenic nerve (*phren* being Greek for diaphragm) and the vagus nerve (*vagus* being Latin for wandering).

The olfactory nerve is the shortest of the cranial nerves, running from nose to the forebrain. It conveys information relating to smell and is involved in the limbic system (parts of the brain that deal with emotions and memories). The olfactory nerve can trigger trauma: “researchers reveal that the olfactory system in the brain is biologically and structurally more sensitive to trauma cues than previously thought.”<sup>12</sup>

The phrenic nerve is the main nerve of the respiratory system and can be associated to some extent with the sympathetic nervous system.<sup>13</sup> It runs between the neck and the diaphragm, having two branches that pass through heart and lung. It passes motor information to the diaphragm and receives sensory information from it. It is the phrenic nerve that regulates our breathing. Without a functioning phrenic nerve, then literally there is no life.

Medical students sometimes learn this rhyme during their training: “C3 C4 C5 keeps the diaphragm alive”. The phrenic nerve connects to those areas on the cervical spine on the Western medicine map of the body. These points link to the acupuncture points of Bladder 9 (Jade Pillow) and Bladder 10 (Heavenly Pillar) from the Chinese medicine map of the body.

Breathing is controlled by the phrenic nerve. In the words of researchers Sohaib Mandoorah and Therese Mead: “The phrenic nerve is among the most important nerves in the body due to its role in respiration. The phrenic nerve provides the primary motor supply to the diaphragm, the major respiratory muscle.”<sup>14</sup> It will be fascinating to see what future research reveals about the phrenic nerve functioning and how this functioning can be improved.

The vagus nerve, the main nerve of the parasympathetic nervous system, supplies parasympathetic fibres to all the major organs of the head, neck, chest, and abdomen. It runs between the brain and the abdomen. Messages go both ways, though most go from body to brain (a common figure for this is about 80%).<sup>15</sup> Essentially the body informs the brain and the brain informs the body. As an example, it is probable that the information that goes from diaphragm to brain has significant importance for our well-being.<sup>16</sup>

The ‘tone’ of the vagus nerve indicates emotional, mental and physical health. Tone is influenced by childhood experiences, genetics and adult life events. This tone can be seen in how resilient we might be. If a person has experienced trauma, their vagal tone will likely be lower. Lower resilience makes a person more prone to experiencing post-traumatic stress; higher resilience means that a person is less likely to exhibit these behaviours. It must be emphasised that these are theories; as one medical practitioner wrote to me personally: “It’s more of a watch this space than this is an accepted fact.”

It is suggested that trauma is not just psychological, it is also physiological. In the words of Bessel van der Kolk, the body does indeed keep the score...<sup>17</sup>

Barbara Frederickson, a psychology professor, explains how vagal tone can change.

Scientists used to think vagal tone was largely stable, like your height in adulthood. Our data show that this part of you is plastic, too, and altered by your social habits. To appreciate why this matters, here’s a quick anatomy lesson. Your brain is tied to your heart by your vagus nerve. Subtle variations in your heart rate reveal the strength of this brain-heart connection, and as such, heart-rate variability provides an index of your vagal tone. By and large, the higher your vagal tone the better. It means your body is better able to regulate the internal systems that keep you healthy, like your cardiovascular, glucose and immune responses...

By increasing people's vagal tone, we increase their capacity for connection, friendship and empathy. In short, the more attuned to others you become, the healthier you become, and vice versa. This mutual influence also explains how a lack of positive social contact diminishes people. Your heart's capacity for friendship also obeys the biological law of 'use it or lose it.' If you don't regularly exercise your ability to connect face to face, you'll eventually find yourself lacking some of the basic biological capacity to do so.<sup>18</sup>

Indicators of vagal tone include a person's body language, their facial expressions and their voice. Researcher Stephen Porges stated "as social human beings, we are much more interested in the intonation of the voice than we are in the content."<sup>19</sup>

What we are expressing with our face shows what is going on in the body, essentially (in the words of Porges): "are we safe to come close to?"<sup>20</sup> There are a multitude of moves (often slight and subtle) that we can do with our hands, tongue, face and eyes that significantly change input for the ANS.

## **COHERENT BREATHING**

Breathing is one of the key ways that we can control our nervous systems and one that is generally easily accessible. When we slow our breathing, it is possible to slow our heart rate – although not always. On occasion, the brain can become confused by slow breathing and believe that it is dying.

It must be made clear that individuals who have been experienced physical, emotional and/or psychological trauma are more likely to struggle with practices that involve breath control (whether lengthening or altering).

As Barbara Frederickson pointed out, vagal tone can be indirectly observed by measuring heart rate variability (HRV). A good way of influencing heart rate variability (and so enhancing our resilience) is through coherent breathing. An acronym for this technique is BREATHE.

- **B**reathe
- **R**hythmically
- **E**venly
- **A**t the **H**eart of the belly
- **E**veryday

A higher heart rate variability has significantly beneficial impacts on health, healing and longevity. In the words of Richard Brown and Patricia Gerberg: "having a higher HRV is associated with...overall greater health and longevity".<sup>21</sup>

By breathing more with the belly, we can perhaps shift away from fear states. Though fear is a basic emotion that has played an essential role in our survival, too much fear can be damaging to our health.

'Breathe from the belly' is a familiar instruction in a yoga class. Yet it is not always easy, even for very experienced yogis. It has been suggested that a difficulty in belly breathing for some yoga practitioners is that an emphasis on *bandhas* (body or energy locks) and strong abdominal areas can mean that diaphragms might be less able to move. As the diaphragm moves, so does the pelvic floor (both move down on the inhale and up on exhale).

Potentially, this diaphragm movement can be disrupted by a too active and too strong *mula bandha* (perineum region). The same is true for people who work to develop their 'abs' (that famed six-pack). Thus then belly breathing/slower breathing could be more challenging. One long-term practitioner told me: "I certainly experienced that when I had a traditional Ashtanga practice." And pelvic floor tension is often associated with anxiety.

## **BELLY BREATHING**

Richard Brown and Patricia Gerberg noted that "belly breathing and coherent breathing ...shift the nervous system response into a healthier balance by activating the healing, recharging part of the

nervous system while quieting the defensive, energy-burning parts.”<sup>22</sup> According to a 2017 research paper, “it is not to be mistaken that slow breathing practice should minimise sympathetic activity, but rather, that it appears capable of achieving optimal sympathovagal balance, and enhancing autonomic reactivity to physical and mental stress...Of great scientific interest is the effect of long-term practice of slow breathing.”<sup>23</sup>

24/7 culture with its striving for hormonal highs (such as the dopamine (a neurotransmitter that plays a role in how we feel pleasure) hit from social media) can mean higher levels of adrenalin (a hormone that can increase blood circulation and breathing and also prepares muscles for exertion). Consequences of this 24/7 culture could be imbalances of the vagus nerve and lowered vagal tone.

Richard Brown and Patricia Gerberg wrote: “When people are under stress, their breathing becomes shallow and their shoulders tend to go upward.”<sup>24</sup> A possible path of lessening stress is consciously avoiding sources of intense stimulation; a friend said the best way to be happy about social media is not to be on social media...

Other possible paths of lessening stress and so increasing connectivity are slower breath and softening shoulders away from ears. How to be more happy and more fulfilled and more productive? Be less anxious...

A few suggestions:

- breathe slowly
- speak with smiles and changing vocal sounds — though being careful that we are not appeasing too much as this could place us lower on the dominance hierarchy and thus more vulnerable to illness and trauma
- exercise our social relationships, as social bonds are good for our health
- when we feel safer, we are more likely to get physically closer with other people which assists social bonding

## MORE ON THE VAGUS NERVE

In the brain, the vagus helps to control anxiety and depression. In the heart, it controls heart rate and blood pressure. In the liver and pancreas, the vagus nerve helps to control blood glucose balance. In the gallbladder, it helps release bile, which can help get rid of toxins and break down fat (excessive cortisol can lead to fat, particularly around the abdomen).

The vagus nerve promotes general kidney function. Vagus activation also releases dopamine in the kidneys. In the tongue, it helps to control taste and saliva; in the eyes, it helps to release tears; and it influences the release of oxytocin (a hormone that plays a role in social bonding).

Here are seven simple ways to stimulate the vagus nerve and so reap these benefits throughout the body.

- 1) **Cold** studies have shown that when the body adjusts to cold, the sympathetic system declines and the parasympathetic system increases (as there is constricting of blood vessels). A splashing of face with cold water can be a start; cold showers and cold water swimming can be great.
- 2) **Singing and chanting** this includes humming, mantra chanting, hymn singing.
- 3) **Yoga, meditation** (particularly loving-kindness forms of meditating), **mild exercise** and **movement forms** like tai chi.
- 4) **Positive social relationships** and **laughter**
- 5) **Probiotics, quercetin** (found in green tea, ginkgo biloba, apples, etc), **Vitamin C** this is the gut-brain connection.
- 6) **Gargling** this stimulates the muscles of the palate which are fired by the vagus nerve.
- 7) **Resting and sleeping on your right side** Studies have found that laying on the right side increase heart rate variability and vagal tone activation more than being on the left side.<sup>25</sup>

Here are three fascinating facts about the vagus nerve.

- A person has been brought out of a vegetative state and back to consciousness through vagal nerve stimulation.<sup>26</sup>
- Recent evidence has shown that stimulating the vagus nerve after a stroke can help to recover motor function.<sup>27</sup>
- Implants of electrical nodes that work as an artificial vagal nerve (and thus stimulate the vagus nerve) have been effective for people suffering from anxiety, depression and autoimmune diseases.<sup>28</sup>

It must be emphasised again and again that these are theories and ideas. The neuroscientist and writer Sarah McKay wrote: “The question as to whether fear of snakes and spiders is learned or innate has been studied...results are mixed! Some studies of babies show they have an innate stress-response to viewing snakes, others show they don’t have an innate response. That’s what makes this whole topic so interesting – the science is continually evolving.”<sup>29</sup>

## SO WHAT DOES THIS MEAN TO ME?

A question can be: where am I on the see-saw of parasympathetic activation and sympathetic activation? What do I need to do to become better balanced? More rest or more mobilisation? Putting legs up the wall, child’s pose, warm bath, hugging a tree? Or brisk walking, some sun salutes, bouncing on a ball, dancing to disco? Perhaps this could be called Intelligent Dialogue Yoga...

This Intelligent Dialogue Yoga can be grounded by attending to our nervous systems. Then we can consider our aspirations. Do we describe ourselves as happy, active, interested and see the world as safe, fun, peaceful? Or do we describe ourselves as angry, depleted, anxious and the world is dangerous, chaotic, unfriendly?

Maybe practices such as Yin yoga that promote slowing down, turning away from high levels of external stimulation, encouraging ease in the body might partially create conditions that cultivate this aspiration and help answer that question.

When we feel threats, we feel more threatened. When we feel safe, we feel more safety. Like the domino effect, there is a cascading of consequences...

*Norman Blair*  
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*In writing this article, I received feedback/ suggestions/ advice from 20 people. An example of hive mind in action. These people include medical professionals, yoga teachers, psychologists, yoga therapists, autodidacts. At the end of the day, I take responsibility for what is written here and I acknowledge there can be mistakes and obviously new ideas emerge and views change. This is an ongoing process with a potential wish being expressed in the words attributed to Dr Seuss: “You are you. Now, isn’t that pleasant?”*

## Notes

- 1 Elliott L Mancall and David G Brock. 2011. Gray’s Clinical Neuroanatomy EBook. Elsevier, p 3.
- 2 Ronan O’Rahilly et al. 2004. *from Basic Human Anatomy: A Regional Study of Human Structure*. [https://www.dartmouth.edu/~humananatomy/part\\_1/chapter\\_3.html](https://www.dartmouth.edu/~humananatomy/part_1/chapter_3.html)
- 3 Charlotte Watts. 2018. *Yoga Therapy for Digestive Health*. Jessica Kingsley, p 59.
- 4 Nicolette Lanese. ‘What is Homeostasis?’. *Live Science*. 15 July 2019. <https://www.livescience.com/65938-homeostasis.html>

- 5 Iain McGilchrist. 2009. *The Master And His Emissary*. Yale University Press, p 69: “There is some evidence that, whereas sympathetic nervous control is more influenced by right hemisphere, control of the parasympathetic nervous system is more under left-hemisphere control.”
- 6 Christine Guo et al. 2016. ‘Dominant hemisphere lateralization of cortical parasympathetic control as revealed by frontotemporal dementia’. *PNAS*. 26 Apr 2016. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4855566/#r21>
- 7 L Sanjay Nandam et al. ‘Cortisol and Major Depressive Disorder—Translating Findings From Humans to Animal Models and Back’. 2019. *Frontiers in Psychiatry* 10: 974. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6987444/>
- 8 Aarushi Khanna. ‘Control of the Heart Rate’. *Teach Me Physiology*. 12 January 2021. <https://teachmephysiology.com/cardiovascular-system/cardiac-output/control-heart-rate/>
- 9 Robert Putnam. 2000. *Bowling Alone: The Collapse and Revival of American Community*. Simon & Schuster, p 332.
- 10 <https://geeky.yoga/2020/10/10/is-yoga-community-good-for-our-immunity/>
- 11 Judith Herman. 1992. *Trauma and Recovery: The Aftermath of Violence: From Domestic Abuse to Political Terror*. Basic Books, p 56.
- 12 ‘New Study Indicates That Sense of Smell Could Play Major Role in New Approaches to Treating PTSD’. Oct 5, 2015. <https://www.mcleanhospital.org/news/new-study-indicates-sense-smell-could-play-major-role-new-approaches-treating-ptsd>.
- 13 “Communicating fibres between the phrenic nerve and sympathetic nervous system may exist.” Thomas J. M. Verlinden et al. 3 Aug 2018. ‘The human phrenic nerve serves as a morphological conduit for autonomic nerves and innervates the caval body of the diaphragm’. *Scientific Reports*. <https://www.nature.com/articles/s41598-018-30145-x>
- 14 Sohaib Mandoorah and Therese Mead. ‘Phrenic Nerve Injury’. *StatPearls*. 13 Aug 2020. <https://www.ncbi.nlm.nih.gov/books/NBK482227/>.
- 15 Bruno Bonaz, Thomas Bazin and Sonia Pellissier. December 2018. ‘The Vagus Nerve at the Interface of the Microbiota–Gut–Brain Axis’. *Frontiers in Neuroscience*, p 49. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5808284/>
- 16 Sigrid Breit et al. ‘Vagus Nerve as modulator of the brain-gut axis in psychiatric and inflammatory disorders’ *Frontiers in Psychiatry*. 13 March 2018. <https://www.frontiersin.org/articles/10.3389/fpsy.2018.00044/full>
- 17 Bessel van der Kolk. 2014. *The Body Keeps The Score: Brain, Mind, and Body in the Healing of Trauma*. Penguin.
- 18 Barbara Frederickson. ‘Your Phone vs Your Heart’. *New York Times*, 23 March 2013.
- 19 National Institute for the Clinical Application of Behavioral Medicine. 2012. *Body, Brain, Behavior: How Polyvagal Theory Expands Our Healing Paradigm*. Interview of Stephen Porges by Ruth Buczynski, p 8. <https://www.stephenporges.com/articles>.
- 20 National Institute for the Clinical Application of Behavioral Medicine. 2012. *Body, Brain, Behavior: How Polyvagal Theory Expands Our Healing Paradigm*. Interview of Stephen Porges by Ruth Buczynski, p 10. <https://www.stephenporges.com/articles>.
- 21 Richard Brown and Patricia Gerberg. 2012. *The Healing Power of the Breath*. Shambhala, p 11.
- 22 Richard Brown and Patricia Gerberg. 2012. *The Healing Power of the Breath*. Shambhala, p 10.
- 23 Marc Russo et al. 2017. ‘The physiological effects of slow breathing in the healthy human’. *Breathe (Sheff)*. Dec 2017. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5709795/>
- 24 Richard Brown and Patricia Gerberg. 2012. *The Healing Power of the Breath*. Shambhala, p 126.
- 25 Joe Cohen. ‘19 Factors That May Stimulate Your Vagus Nerve Naturally’. *Self-Hacked*. 1 Oct 2020. <https://selfhacked.com/blog/32-ways-to-stimulate-your-vagus-nerve-and-all-you-need-to-know-about-it/>
- 26 Karen Weintraub. ‘Man Partly Wakes From 15-Year Vegetative State — What It Means’. *National Geographic*. 25 Sept 2017. <https://www.nationalgeographic.com/news/2017/09/vegetative-state-vagus-nerve-stimulation-health-science/>
- 27 University of Texas at Dallas. “Vagus nerve stimulation boosts post-stroke motor skill recovery”. *ScienceDaily*. 27 March 2018. <https://www.sciencedaily.com/releases/2018/03/180327162606.htm>
- 28 John P O’Reardon, Pilar Cristancho and Andrew D Peshek. May 2006. ‘Vagus Nerve Stimulation (VHX) and Treatment of Depression’. *Psychiatry (Edgmont)* <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2990624/>
- 29 Sarah McKay. ‘Rethinking the Reptilian Brain’. *DrSarahMcKay.com*. 24 June 2020. <https://drsarahmckay.com/rethinking-the-reptilian-brain/>