

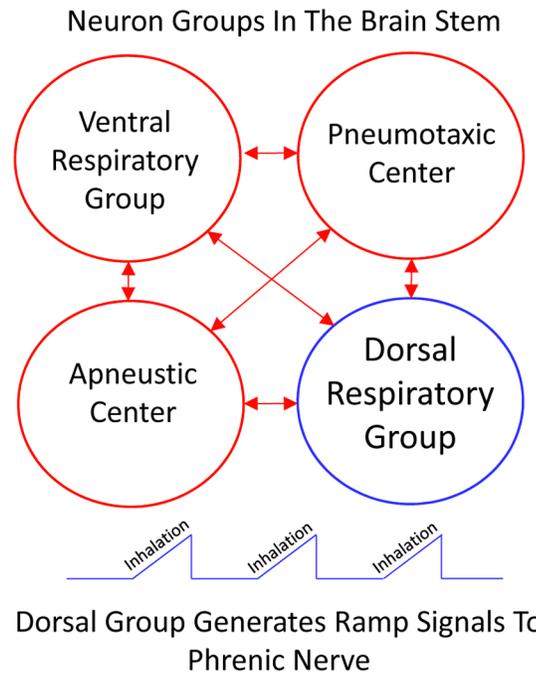


Hello all,

Welcome to Volume 2, Issue 4 of Swan & Stone: *A Matter Of Consciousness?* I've written a great deal about breathing and how breathing is a *bridge*, i.e. it is a function that can be controlled willingly, but when we're not exerting *conscious* control, breathing progresses on its own under control of the autonomic nervous system. In this issue, we'll explore what is known about how this works.

The *phrenic nerve* innervates the diaphragm facilitating bidirectional nervous function, both motor and sensory. Referring to Figure 1, signals are generated in the brain stem and communicated via the phrenic nerve resulting in flexion (inhalation). These signals are referred to in medical literature as *ramp* signals, where the amplitude of the ramp corresponds to diaphragm flexion. Between ramps there are periods of inactivity, allowing the elastic recoil of the chest to return the diaphragm and lungs to their nominal resting position, thereby facilitating exhalation. These inspiratory ramp signals are generated in the "dorsal respiratory group" of neurons in the brain stem and represent a form of clock signal that never stops. It has a nominal period of 5 seconds, ramping up for 2 seconds and then stopping abruptly for 3 seconds. Consequently the dorsal respiratory group alone would have us breathe at 12 breaths per minute with a 2 second inhalation and a 3 second exhalation. Interestingly, 17-19 breaths per minute is the average breathing rate of the adult population. But control of breathing (of diaphragm motion) is more complicated than this, having at least 3 other centers in the brain stem that contribute to its management. The 2nd function is the "pneumotaxic center" located in the upper aspect of the brainstem and its job is to control the period of the ramp signal generated by the dorsal respiratory neurons. A strong signal shortens the ramp and increases breathing frequency and a very small signal lengthens the ramp and decreases breathing frequency. *Medical Physiology* uses examples of 30-40 breaths per minute as the rapid breathing rate and 3-5 breaths per minute as the slow breathing rate as a consequence of pneumotaxic center influence. There is a 3rd group of neurons located in close proximity to the dorsal group, this being the "ventral respiratory group" which engage when there is a need for increased pulmonary ventilation. To add to the complexity, there is a 4th center, the "apneustic center" about which little is known, but that it appears to work in concert with the pneumotaxic center to govern the length and fullness of inspiration, and is associated with gasping. Exactly how these centers work together, under control of both autonomic and somatic functions remains unclear. (The major reference for this discussion is *Medical Physiology*, Guyton & Hall, 2002.)

As we know that *breathing is a bridge* and that we can exert conscious control over both inspiration and expiration, or relegate breathing to autonomic oversight, it is clear that however they work, these centers can be influenced consciously. Looking at the numbers above, we might conclude that the average rate of 17-19 breaths per minute of the typical adult implies that there is little conscious regulation of breathing at work in that cohort, that the typical adult's breathing is indicative of almost purely autonomic influence. Obviously we are influencing these centers via the practice of Coherent Breathing – we are exerting conscious control that has huge guidance over the ultimate outcome of "the ramp" signal. We are lengthening the ramp to realize a nominal breathing rate of 5 breaths per minute and we are equalizing it such that periods of inhalation and exhalation are equal. My thesis is that this governance sets up the conditions for resonant circulation where both thoracic and abdominal pumps are contributing substantially to the flow of blood upward against the force of gravity, primarily as a consequence of diaphragm motion, and that blood flow in the venous and arterial trees is equal, though dynamic. These 4 groups of neurons may have evolved over time, giving us more conscious control so as to help support uprightness of humankind such that we can move and function optimally while erect.



Dorsal Group Generates Ramp Signals To Phrenic Nerve
Figure 1: Diaphragm Control Originates In The Brain Stem In The Dorsal Group But Is Modifiable By Other Centers.



17-19 breaths may work fine for a cold blooded lizard warming itself on a rock – but not for humankind. The more I look into it, the more convinced I become that humankind has evolved, both mentally and physically to be as we are because we adapted over time to standing and walking erect, defeating gravitational force that would otherwise keep us relatively horizontal and close to the ground. A key question arises from this musing....

Is there a positive effect on humanity from breathing well, and is there a negative effect from breathing poorly, where by “poorly” I mean by not exerting conscious influence over what may otherwise be a reptilian breathing pattern. Here I exaggerate to make a point – or more troubling, maybe not. In previous writing, I’ve urged you to teach your children well to breathe, as it may end up that breathing well plays a major part in their development, in who they end up becoming, as a person. We already know that children that breathe well do better in school. What about development of their other mental and psycho-social processes? The yogic school of thought is that one can literally evolve one’s consciousness via breathing – and by doing so, *change who we are* for the better. I’ve been at this long enough to agree with this notion. By breathing well over the long run, everything changes. I believe that this is ultimately due to proper circulation of blood and fluid throughout the body but in particular to the brain, the home of the mind.

Figures 2 and 3 show the intricate design of both phrenic and vagus nerves and their descension from their origin at the cervical vertebrae down through the core of the body, both in close proximity to the heart and pericardium. The phrenic nerve is duplicated, such that the left branch controls the left side of the diaphragm and the right branch controls the right side. It is possible to damage one branch, where diaphragm motion on one side of the body becomes inhibited but the alternate diaphragm half continues to function. This makes sense in that breathing is a life or death matter.

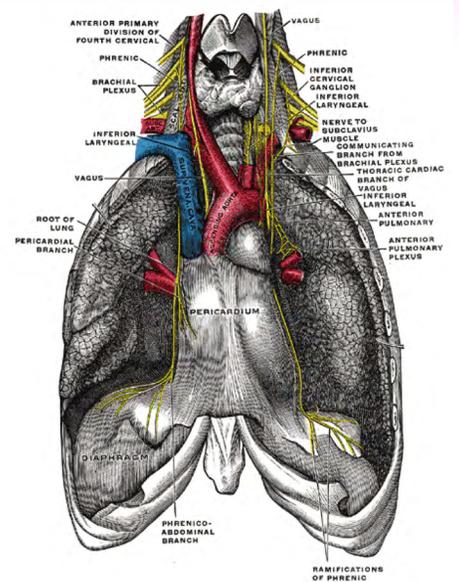


Figure 2: Gray's Anatomy Depiction Of Chest With Distribution Of Both Phrenic And Vagus Nerves (Illustration In Public Domain)

Figure 3 depicts a cross section of the chest where we can see the locations of the phrenic and vagus nerves relative to the heart, lungs, and pericardium, left and right phrenic nerves sandwiched tightly between the cavities of the pericardium and the cavity of the pleura, and remain closely tied to the pericardium during their entire descent. There is some speculation that there is communication going on between the phrenic nerve and the pericardium along the way, this communication playing a part in the phenomenon of heart rate variability. But, while the vagus nerve is front and center in most discussions of nervous system management, there isn't much attention paid to the *phrenic nerve* in general. Yet, action of the phrenic nerve is a determinant of vagal activity, this because it controls the diaphragm, which ultimately controls the rise and fall of blood in the circulation and alternatively the swing of the autonomic nervous system from parasympathetic to sympathetic emphasis as a consequence of baroreception, cyclic action ultimately communicated throughout the body via the vagus nerve.

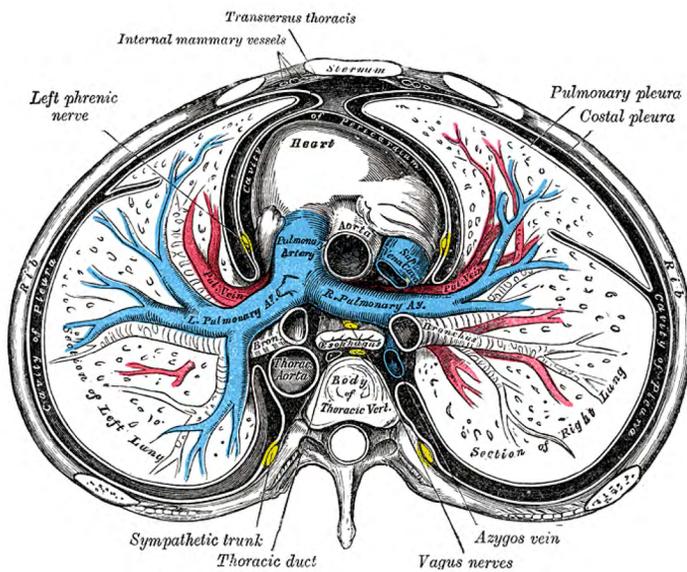


Figure 3: Gray's Anatomy Depiction Of Chest Cross Section With Distribution Of Both Phrenic And Vagus Nerves (Illustration In Public Domain)

The phrenic nerves are the nerves of breathing. The vagus nerve follows. The primordial biology of the brain stem is clearly organized to allow us conscious control over how we breathe. The question is whether or not we assume conscious control over the process. I argue that health, well-being, performance, and longevity depend on it, and may be even *the cultivation of human consciousness*.

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