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Hello all,

Welcome to ***Jade: A Thesis On Giraffe Circulatory Physiology***, ***Volume 2, Issue 5*** of ***Swan & Stone,*** an occasional journal of complementary solutions for health, well-being, performance, and longevity. Readers familiar with my work since the advent of *Valsalva Wave Pro* in 2009, know of my theory that the diaphragm plays a major role in the circulation of blood, and I argue, evolved to aid in the flow of blood upwards against the force of gravity, which would otherwise keep blood pooled in the lower half of the body. Of course this is problematic for land dwelling mammalian vertebrate life because the brain is housed in the head which is held highest and is critically dependent on circulatory effectiveness to function optimally - *if not normally*.

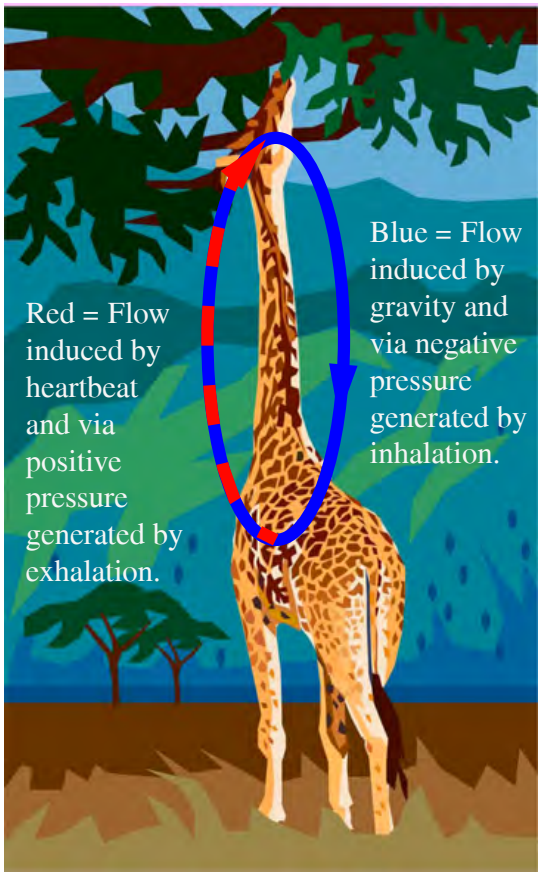

Figure 1: The Giraffe
The extreme example of diaphragm evolution in support of vertical height and circulation.

If you are new to this idea, the argument is that the diaphragm exists not just to facilitate "breathing", moving air in and out of the body, but that internally it is also moving blood such that blood and air meet and part in a synchronous manner, venous blood (depleted of oxygen and rich in CO_2) being presented to fresh incoming air across the very thin alveolar surface of the lungs, this synchrony facilitating the exchange of blood gases, an ongoing process without which the body would perish within a matter of minutes. The current state of the science of respiratory physiology recognizes this blood moving diaphragm function on a breath-by-breath basis, but fails to attribute any circulatory function or advantage to it beyond this. The state of circulatory science is about the same – *the diaphragm exists to facilitate breathing* – that is all. My argument is that the diaphragm plays a vitally important part in both the quality and quantity of circulation in the body, including the circulation of the 37 liters of fluid in the average adult body that is not blood. Here I speak of cellular fluid, extra-cellular fluid, cerebro-spinal fluid, etc. But I am particularly interested in the effects of breathing and consequent circulation on the brain and its myriad functions, including the cultivation of human capabilities that we tend to think of as being associated with *higher order consciousness,* extra sensory perception, psychic communication, subconscious problem solving, high IQ (?), and of course higher order human emotion, though I hesitate to parse. I prefer to think of the collective as the wholistic capacity of a highly functioning human body/mind.

A brief study of vertebrate life forms seems to support the thesis that diaphragm sophistication evolved with erectness, i.e. we can see that the more erect the species, the more evolved the diaphragm. (Water dwelling mammals are not treated here). Reptiles and amphibians employ axial musculature and proto-diaphragms, less complex and evolved structures that allow them to breathe air and hold their breath. The giraffe, a unique evolution of the camel family, is the quintessential example of extreme evolution of erectness. Scientists have been studying the giraffe for many decades to understand how it is possible for the giraffe to exist, given its extreme vertical stature and the fact that its heart is no larger than other mammals relative to its body mass. Many giraffes have been sacrificed to science via terminal invasive instrumentation to understand this riddle – this includes studies in relatively recent times. In review, *the fundamental problem with these studies is that in zoological science – just as in current state-of-the-art human physiology, there is no recognition that diaphragm movement plays a major role in the circulation of blood. But whereas the human body can function (at least to a degree) when the diaphragm is not functioning beyond mere adequacy, the giraffe body cannot – where I argue, that due to both the length of its neck and its legs, if its diaphragm were not contributing to circulation, it would not be able to stand, or possibly even lift its head.* ***In January of this year, at the invitation of The Dallas Zoo, I had the good fortune to explore this theory.***

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Jade is a 12 year old female giraffe that needed her hooves trimmed. As she is not one to submit to a manicure willingly (which I learned that some are) she had to be sedated before the procedure. While this may sound like an insignificant veterinary event, for a giraffe - it isn't. Approximately 30 animal handlers, hospital, and zoo management personnel were present, the two farriers and myself forming a group totaling ~33. In short, the procedure involved sedating her and then gently lowering her body to the ground, while holding her head high, her neck gradually coming to rest on a ramp inclined at about 45 degrees. Once in position, the team rapidly went to work checking vital signs, obtaining samples, and of course, trimming hooves, the entire time massaging her neck, which I learned is quite delicate, the entire length having 7 very long vertebrae, just like the human neck. I was able to attach the *Valsalva Wave Pro* sensor to the tip of her tongue which was flaccid and hanging down just a few feet in front of my face. From this vantage point I could also witness her incredible breathing, which was like the roar of a freight train, her hairy nostrils flaring upon inhalation vs. exhalation, something I've never witnessed in any other animal. *Again, her inhalation was so powerful that her nostrils flared when she inhaled,* a clear indication that her inhalation was incredibly powerful. The reason for my emphasis on this point will become clear in a moment...

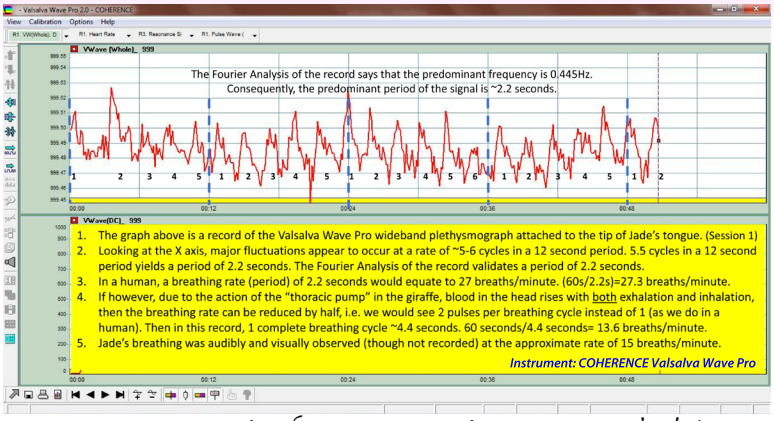

Figure 2: Record Of 1st 48 seconds (VWave Whole).
Click the image to open a larger image. Zoom for clarity.

My keen interest in the giraffe comes from these facts:

1) The giraffe carries its brain higher above its chest than any other land dwelling mammalian vertebrate,
2) The giraffe heart is on-average no larger than that of other mammals, per body mass, and most interesting to me,
3) The giraffe has the largest diaphragm of any land animal relative to its body mass.

As the reader can see by now, I want to know if both the overall height of the animal, and in particular, the length of the neck are allowed by the size (and use) of its diaphragm? When a human body is breathing slowly deeply and rhythmically, i.e. "coherently", a large wave of blood exits the lungs with each exhalation and is amplified by the left heart, a portion traveling up the ascending aorta to the head and brain, and a portion traveling down the descending aorta to the rest of the body. During inhalation, an equal volume of blood is drawn into the lungs from the venous tree via the right heart to meet incoming air across the alveolar surface, in the great scheme of things, blood in venous and arterial trees remaining equal though dynamic.

My theory is that the human and giraffe share much in common, that the giraffe is an extreme case of "thoracic pump" evolution, where "breathing" generates the additive motive force that both propels blood up the neck via the carotid artery during exhalation and down the neck via the jugular vein during inhalation. (Note that the thoracic pump exerts this effect on the *entirety* of arterial and venous structures coincident with diaphragm movement, i.e., it generates positive pressure on the arterial tree via the left heart during exhalation and negative pressure on the venous tree via the right heart during inhalation.)

An interesting aside is that as early as the 1950s, the theory was proposed that blood made it to the giraffe's head, aided by what was referred to as the "U-tube" effect, this being that gravitational force on blood descending in the jugular vein, effected enough negative pressure (vacuum) on the arterial side of the neck and head to draw blood upward over the incredible length of the neck to the head and brain. Decades were spent studying this hypothesis but in the end, it is determined that gravity exerted on venous blood cannot exert adequate negative pressure to cause blood to rise on the arterial side. And, in the absence of the knowledge of the diaphragm and associated "thoracic pump", almost a century has passed with the riddle of giraffe circulatory viability unsolved.

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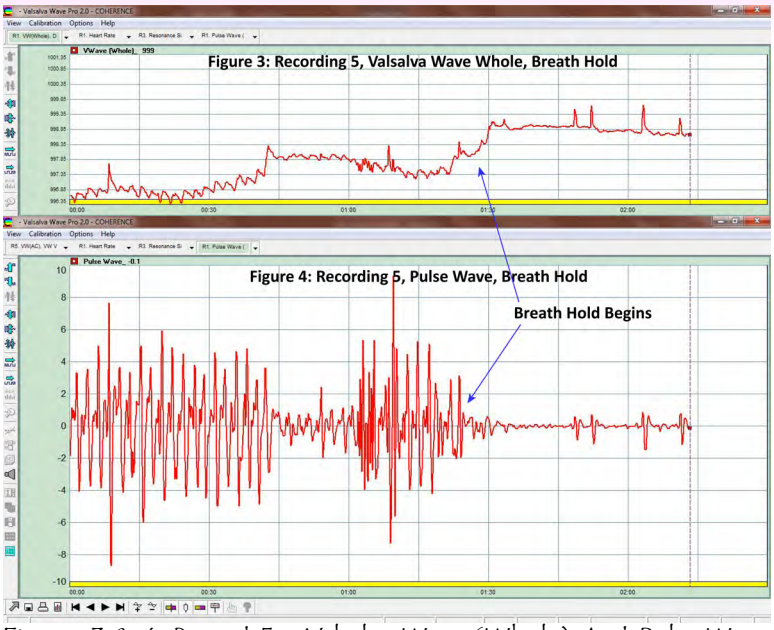
My theory is simple: That giraffe circulatory physiology depends on both exhalation to send blood up the carotid artery to the brain, and equally (if not more so) on inhalation, to draw blood down the venous side returning it to the heart and lungs. This theory was borne out during my visit with Jade in numerous ways.

First, her inhalation was at least as powerful as her exhalation (if not more so, nostrils flaring coincident with inhalation). Clearly, it is imperative to get fresh air to the lungs, and the force required to move a large volume of fresh air down the length of the neck is huge - *but what has not been recognized is that this huge force exerted by the diaphragm to fill the lungs with air is also exerting a strong vacuum on the venous tree, throughout the giraffe body, including the jugular vein and legs.*



Figures 3 & 4: Record 5 – Valsalva Wave (Whole) And Pulse Wave During Breath Hold.

The *Valsalva Wave Pro* recording of page 2, Figure 2, clearly shows blood rising at the tip of Jade's tongue at twice her respiratory rate, i.e. blood rises in the tongue during exhalation (as it does in humans), and again during inhalation (not observed in humans). The major wave component is respiratory. The heartbeat is evident but relatively small.

More evidence comes in Record 5, where we see the "Pulse Wave", the measure that we normally use with *Valsalva Wave Pro* to detect the heartbeat. But here we see that at the tip of Jade's tongue, the heart beat is almost invisible, the signal heavily dominated by the wave generated by her respiration. About 90 seconds into Record 5, Jade does something completely unexpected by me – *she held her breath*, something that I could not possibly have hoped for. When she did, the audible roar of her breath stopped cold. Yikes! After a few moments, I tapped Diana on the arm to say, "Is she alright?" Diana replied that, "Oh yes, giraffes do that from time to time to self-regulate blood gas levels." The reason Jade's breath hold was important to me is that I could see the contribution of heartbeat vs. breathing to blood activity at the tip of her tongue.

Figures 3 & 4 capture that moment. Figure 3 is of Valsalva Wave (Whole), the same measure as Figure 2, but at a slightly different scale. Figure 4 is "Pulse Wave" an AC signal that Valsalva Wave Pro uses as the basic detection of heart rate in humans, the rise-rise interval being the basis of the heart rate variability (HRV) measure. Note that in Jade's record, when the breath hold begins, signal amplitude drops to near zero, indicating that when breathing is not in progress, the heart beat is barely visible in the head. Almost all of the amplitude of Figure 4 is a function of breathing. In this last recording I witnessed the breath hold start but in the end I was not able to witness it end, as everyone but the handlers were given the clear and urgent signal to exit the room so that Jade could resume consciousness and get back on her feet – which she did! Once we were all outside the fenced in area, I watched her head rise up *like she was on an elevator*, straight up, no wobble, no weave, a beautiful and quite incredible feat of grace, balance, and poise.

For us, my thesis is this: *As land dwelling mammals, our evolution, very much like that of the giraffe, probably depended on our ability to use our diaphragms both consciously and unconsciously, in order to stand, run, survive, and thrive. It still does – the reason we must stand tall and breathe!*

Stephen Elliott, President, COHERENCE LLC

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