

Nerves and the embryological fluid force

Andrew Cook MSc RCST
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Part of a series of essays on the human body-mind, available at
<http://www.hummingbird-one.co.uk/resources2.html>

1. Introduction

Much of the background material for this essay has been covered in two previous essays : *Swedenborg, Jello and the Tides*¹ and *A few implications of Structured Water on Bodywork and Movement with respect to Muscles*².

The foundation for the core of the material we will be looking at is found in two main sources : Gerald Pollack's *Cells, Gels and the Engines of Life*³, and the spiritual and scientific works of Emanuel Swedenborg (1688-1772)⁴ whose works are translated and published by the Swedenborg Society⁵. David Fuller DO has recently published a comparison of the philosophy of Swedenborg with the writings of both AT Still and WG Sutherland⁶.

Much has been spoken of the fluid forces that drive embryological development and form the basis for health in the adult. Not only is this a theory in craniosacral textbooks, but there is a substantial basis of experience of these forces and fields, both from a cranial practitioner perspective and from the point of view of people who have received treatments from a range of different types of bodywork; and these formative fluid forces are also recognised in mainstream embryology⁷. In the adult's body memory these fluid fields are both subtle and difficult to access, but also often reveal themselves in ways that are both powerful and unforgettable. We can only guess at the way that the embryo experiences them, based on our retrieved body memories, but there is something of a sense of a continuing stream of marvels and glories which warp, transform, expand and unfold the physical being and consciousness of the embryo in a series of spherical gestures.

However, so far there has been very little way of reconciling the intensely spiritual nature of these events with their physical and physiological reality. There has been too large a gap between the dots to be even vaguely comfortable that cell physiology can be expected to meet the far more symbolic experiences that arise in this parallel world. Pollack's new description of cellular function as a series of water phase-changes (in a cell that is Gel rather than liquid) provides a bridge between the physical and the esoteric that is well worth studying. And (at

1 <http://www.hummingbird-one.co.uk/pdf/Jello.pdf>

2 <http://www.hummingbird-one.co.uk/pdf/Muscles.pdf>

3 Gerald H Pollack (2001) *Cells Gels and the Engines of Life*. A new, unifying approach to cell function. Publ. Ebner & Sons, 305pages ISBN 0962689521

4 http://en.wikipedia.org/wiki/Emanuel_Swedenborg

5 <http://www.swedenborg.org.uk/>

6 David B. Fuller (2012) *Osteopathy and Swedenborg*. 624 pp. Hardback, ISBN: 978-0-910557-82-5 available from <http://swedenborg-philosophy.org/publication/index.php?page=1001#Osteopathy>

7 Erich Blechschmidt & Brian Freeman (2004) *The Ontogenetic Basis of Human Anatomy: The Biodynamic Approach to Development from Conception to Adulthood*. Publ. North Atlantic Books, 272pages.

least to myself) it makes most sense when combined with the extraordinary writings of Swedenborg. Which is perhaps not surprising, considering that Swedenborg's ideas appear to be one of the principal foundation stones of Osteopathy, and therefore of Craniosacral work.

2. Swedenborg on Cerebrospinal Fluid

Again, much of this has already been covered, but to recap :

As far as we can tell, Swedenborg may have derived his biological knowledge from

- (a) his initial training at university, which was much influenced by Descartes; who may not have been quite so logical and “mind over matter” as modern rationalists would like to think. An interesting illustration from Descartes is on Malcolm Hiorts website⁸.
- (b) meditation and insight practices, where he experienced his own body working from the inside. This certainly formed the basis of the work of entire second half of his life, and his early writings suggest that he was already on this path at an early age. This may also have included clairvoyance or some other form of direct transmission of knowledge.
- (c) Applying his own scientific method – he studied with and read the best anatomists of his day, synthesised all the material and then meditated on what might be thought of as its “meaning” (from the point of view of discovering how spirit manifests in the body) until the resultant model/interpretation resulted in a profound sense of peace.

His written work on the anatomy and functioning of the brain (written c1750) was a state-of-the-art text until the early 20th century. At that point in history, medical science started to reinvestigate the brain and so much of Swedenborg's work appeared to be erroneous. However, in the light of modern discoveries, his description of the motion of the brain and cerebrospinal fluid appears to be correct in every detail.

The driving force behind all of Swedenborg's work was a desire to understand the way that the Divine force enters and works with Nature (Mankind being part of that Nature).

He considered that all processes occur on parallel chains of triplets or “*Discrete Degrees*”. Each chain of process informs the processes it feeds *and* the ones that feed it *and* the ones that it connects to, and so although it is possible to isolate a triplet of causality, then (except for the initial act of creation) this cannot be considered to be fundamental in any way. The modern view that one uses science to find the cause to the exclusion of all other possibilities would be totally foreign to his way of thinking. Thus, any intimation of unique causality here should be taken in this larger context. And it should be understood that this is an exercise in joining dots – and not an exclusive formula for the workings of the body. A more extended description of Discrete Degrees can be found in references (1) and (6).

8 <http://www.craniofascial.com/pages/descrates.htm>

Swedenborg states that the spiritual force enters the body with cerebrospinal fluid (CSF) as it (the CSF) is being produced in the parenchyme (the mass of the brain). This then flows into the ventricles where it adds to the “pure lymph” that is produced there, then travels down the nerves and enters the body through the nerves (synapses?). From there it mixes with fluid lymph, and eventually returns to the general circulation.

For the purposes of this essay, we focus on the statement that the spiritual force is a parallel “Degree” to CSF, in that it moves with the CSF - but is not necessarily dependent on the same transport processes or indeed dependent on CSF. There is instead a mutuality in that if one is able to flow, the other is also more able to do the same. Its pathway is more or less the same as the CSF, and its spiritual function in the body is in some way paralleled by the physiological function of the CSF (that is being transported by nerves).

Thus we have two aspects that are of immediate importance here :

- i. The CSF flows through the neurons and (ideally) exits from them throughout the body
- ii. There is a parallel spiritual force (Wisdom, Love) that enters the body and follows more or less the same pathway
- iii. The two are mutual but not rigidly so; when one moves it facilitates the other, and when one is blocked the other *may* also be affected.

3. Pollack on Microtubules

Again we here will only focus on the elements that are relevant to the essay, and Chapter 12 of Pollack (*op cit*) is thoroughly recommended.

Microtubules have two zones that can sustain some kind of reaction. As their name suggests, they have an inner tube. And they have an outer shell. And the two zones meet at the ends of each microtubule.

Penrose and Hameroff⁹ and Zohar¹⁰ have proposed that microtubules are the main physical component of the body that has an aperture of the correct dimensions to sustain a Quantum field, and which also is sufficiently plentiful in the body (and particularly in neurons) to be capable of being a good candidate for the physical seat of consciousness. Zohar considered that body consciousness plays out as a Bose-Einstein Condensate (BEC), whose particles are in mutual resonance – including phase resonance, just as photons are in a laser beam. This allows for global consciousness, and also subdomains of consciousness with the possibility of mutual overlapping – in fact, the BEC model is very good at qualitatively describing the various ways that consciousness and memory may play out in the body. Whether that means it is correct – we are quite a way from being able to confirm or deny that. However, for now, it is worth remembering this possible function of the *tubes* of microtubules.

9 <http://www.quantumconsciousness.org/penrose-hameroff/consciousevents.html>

10 Dana Zohar (1990) *The Quantum Self*. Publ Flamingo / Bloomsbury ISBN 0747502714

In contrast, Pollack focusses on the outer shell, and notes that each microtubule is capable of sustaining a quasi peristaltic reaction cascade that passes a wavefront (soliton?) of *liquid* water through the structured water that normally surrounds the microtubule. Along with the water, anything that happens to be dissolved or suspended in this liquid water is also passed along the outside of the microtubule. Kinesin has recently captured the imagination as being a “walking molecule”, with its feet striding along a microtubule, transporting a load on its back some 6 orders of magnitude its own weight. In reality the kinesin homunculus is seen to sometimes skip one or even two tubulin molecules, which feat would require it to not only lift this stupendous load, but also be occasionally leaping in the “air”. Something is not right – at the scale this takes place, as soon as the kinesin unsticks both its feet from the tubulin and enters liquid water, it would have the greatest difficulty finding its footing again. On the other hand, Pollack's Gel/structured water model has water phase change doing all the work, with Kinesin being the catalyst for a cascade of phase change to water – and then return to structure again as the Kinesin moves further along the microtubule. The microtubule consists of an offset-stacked ring of 9 molecules, which geometrically also forms 9 longitudinal rows. An antegrade or retrograde movement may occur on maybe 1 in 3 of these rows, giving each microtubule the possibility to simultaneously transport packets of fluid both away from and towards the brain.

In a general sense, microtubules are literally the skeletal component of cells, whose presence is fundamentally bound to the function of the centriole. One of their uses is as a rigid element capable of generating cell motion. This includes both external motion and the coordination of many internal processes – this has particularly been researched by Donald Ingber¹¹. Brain neurons, being particularly rich in microtubules, are able to move their synapses across substantial distances.

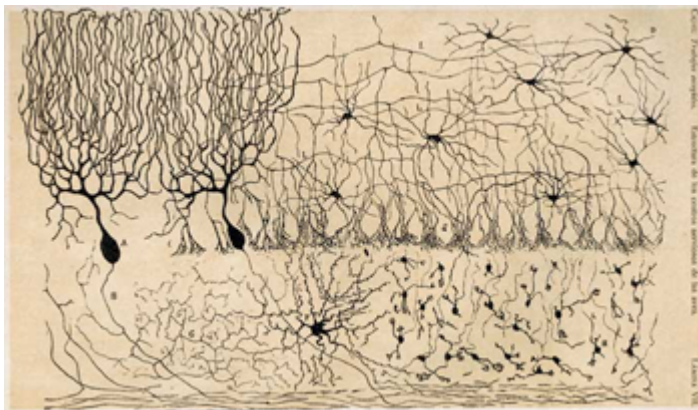


Image from WikiCommons : Drawing of the cells of the chick cerebellum by Santiago Ramón y Cajal, Madrid 1905

Apart from nerve cells, the main concentration of microtubules in the body is in cilia. Every cell in the body has primary cilia (and therefore microtubules¹²). The rods of the eye are one

11 <http://www.childrenshospital.org/research/ingber/Tensegrity.html> – a recent paper available online is at <http://www.childrenshospital.org/research/ingber/PDF/2009/softmatter.pdf> and one example of the hundred or so papers Ingber has co-authored is Mammoto A, Ingber DE. (2009) Cytoskeletal control of growth and cell fate switching. *Curr Opin Cell Biol.* 2009 Dec;21(6):864-70. doi: 10.1016/j.ccb.2009.08.001

12 It would seem that the capacity to signal even predates the presence of a neural system, and that almost all neurotransmitters are present even in a sponge. Does a sponge get high on dopamine?

example of non-motile cilia, and it is possible that neural cells are an evolutionary adaptation of cilia. It would appear that the lining of many non-vascular tubes in the body, including the nose, trachea and walls of the brain ventricles is lined with motile cilia. Pollack describes how the fluid flow around microtubules is almost like a small hosepipe. Therefore motile cilia do not move water by whipping the water like a small propellor, as appears to be the case intuitively when we watch them in action. Instead, the water is pushed by the fluid flow induced by the microtubules. Cilia are therefore analogous to hosepipes (albeit ones where the water flows outside rather than inside the pipe) that are not restrained at their outflow end. The direction of bulk water flow that they cause is a result of how long their tips point in any particular direction. They point one way – there is a reaction as they push water out from their tips, and the cilia is pushed backwards. Eventually it reaches its limit of backwards motion, flips in the other direction, returns, and then starts again. The slightly spiral geometry of the tubulin rings creates a slightly spiral motion of the cilia. The force on surrounding water that can be produced by this mechanism is far more that would be possible of the cilia simply thrashed the water mechanically.

4. Discussion

Flow of CSF in the brain and spine

I would like to start with a short consideration of the flow of CSF within the CNS. Structured water does not flow – it is semi-rigid, semi-crystalline and it just sits there. However – there are many functions in the body that need to have fluid (liquid water) flow so that suitable transport may take place and so that there is an adequate circulation of oxygen, and freedom of motion, etc etc etc. So there must be a balance between the volume of structured water around neurons and glia such that the signalling and metabolic functions of structured water are met – but this volume has to be contained so that CSF can truly flow around and through the brain.

One mechanical force maintaining this balance is the pulsatile force of the arteries in the Circle of Willis. The form of the carotid and cerebral arteries as they traverse the bony cranial base is deliberately dog-legged to reduce and smooth out the peak force of the cardiac pressure-volume pulse. Nevertheless, there is still a substantial peak pressure pulse with each heartbeat, and this has been observed using 4-D MRI imagery (e.g. Enzmann & Pelc 1993¹³). The volume pulse is absorbed by volume changes to the brain's large venous bodies. In fact, this need to neutralise the cardiac pressure-volume pulse gives a primary *raison d'etre* for the cavernous sinus.

<http://scienceblogs.com/neurophilosophy/2009/07/03/evolutionary-origins-of-the-nervous-system/>

- 13 Enzmann DR & Pelc NJ (1993) Cerebrospinal fluid flow measured by phase-contrast cine MR. *Am J Neuroradiol* 14 Nov/Dec pp1301-1307. This paper describes both the flow of CSF and the motion of the brain in response to the (cardiac) pulsatile expansion of cranial arteries, mainly in the circle of Willis. Also see Enzmann DR & Pelc NJ (1992) Brain motion : measurement with phase contrast MR imaging. *Radiology* Dec 185:3 pp653-660

With each heartbeat the brain moves as both Swedenborg (*op. Cit.*) and Magoun¹⁴ describe, performing a double (symmetrical) spiral motion down the spinal canal and then back again. Thus, every heartbeat also sees the brain and CSF squeezed and moved (just as each breath/vertical movement of the respiratory diaphragm squeezes and moves the heart and viscera), creating a rhythm within a rhythm.

Add to this the motion that is imparted by cilia in the ventricles¹⁵, circulating and mixing the liquid water in a controlled manner across the surfaces of the ventricle, and we can begin to recognise a very dynamic hydraulic environment.

The fine and gross hydraulic pore structure of the brain must be very finely tuned to suit fluid balanced flow, and in technical terms, probably has a fractally distributed network of hydraulic porosity, starting from small clumpings of neurons and glia around open pores, and leading up to the pore volumes of the ventricles and sulci. In a general sense the largest pores (i.e. ventricles, sulci) will be either at the start or end of the natural flow path; and more likely the end of it.

It is also a fact that any flow naturally tends to compress the medium which it is travelling through. This is normally not so visible, but a branch of engineering related to filtration, and another related to soil mechanics have found it necessary to account for the compressibility of soft materials across a hydraulic gradient. In everyday life, this can be seen when any fine material (e.g. ground coffee) is filtered – the water flows more and more slowly as it progressively compressed the *filtrate* and reduces its permeability. Up to recently nobody had treated the brain in this way, but a study at Oxford University (Tully, 2008¹⁶) followed by a series of papers¹⁷ has filled this gap. The modelling demonstrates that the brain/parenchyme

14 Harold I. Magoun (1951) *Osteopathy in the Cranial Field* (1st Edition) Published by the American Cranial Association.

15 Yamadori T & Nara K (1979) The directions of ciliary beat on the wall of the lateral ventricle and the currents of the cerebrospinal fluid in the brain ventricles. *Scan Electr Microsc* 3, pp335-340. **Abstract** : The directions of ciliary beat on the wall of the lateral ventricle of the brain have been studied in the mouse by using a scanning electron microscope. As the studies on the directions of ciliary beat on the wall of the third and fourth ventricles were previously completed, a series of studies of the whole ventricular system has now been completed. The pattern of directions of the beat in the brain ventricular system was always the same in every individual examined in the series and this pattern was not contradictory to the anticipated flow of the fluid. Above all, the cilia on the wall of the brain ventricles beat spontaneously. Considering these facts, it was concluded that the ciliary beat has a close relationship with the flow of the cerebrospinal fluid, and conversely the detailed flow of the cerebrospinal fluid within the whole ventricular system was inferred from the ciliary beat.

16 Tully (2008) *Allostasis of Cerebral Water modelling the Transport of Cerebrospinal Fluid*. PhD Thesis, University of Oxford, available online at http://www.academia.edu/972448/Allostasis_of_Cerebral_Water_Modelling_the_Transport_of_Cerebrospinal_Fluid

17 B Tully, Y Ventikos (2009) Coupling poroelasticity and CFD for cerebrospinal fluid hydrodynamics.

Biomedical Engineering, *IEEE Transactions on* 56 (6), 1644-1651

B Tully, Y Ventikos (2011) Cerebral water transport using multiple-network poroelastic theory: application to normal pressure hydrocephalus. *Journal of Fluid Mechanics* 667, 188-215

B Tully, J Byrne, Y Ventikos (2010) Is Normal Pressure Hydrocephalus more than a mechanical disruption to CSF flow? *Engineering in Medicine and Biology Society (EMBC), 2010 Annual*

B Tully, Y Ventikos (2012) Cerebral water transport using multiple-network poroelastic theory: application to normal pressure hydrocephalus. *Journal of Fluid Mechanics* 1 (1), 1-28

JC Vardakis, BJ Tully, Y Ventikos (2012) Multicompartmental Poroelasticity as a Platform for the Integrative Modeling of Water Transport in the Brain. *Computer Models in Biomechanics*, 305-316

must produce most CSF, because if it does not the result is hydrocephalus as the brain tissue is squeezed (due to its hydraulic resistance to flow from the ventricles). There is also a requirement for the neural/glial mass to have a certain degree of rigidity so that it can spring back into shape after each cardiac pulsation.

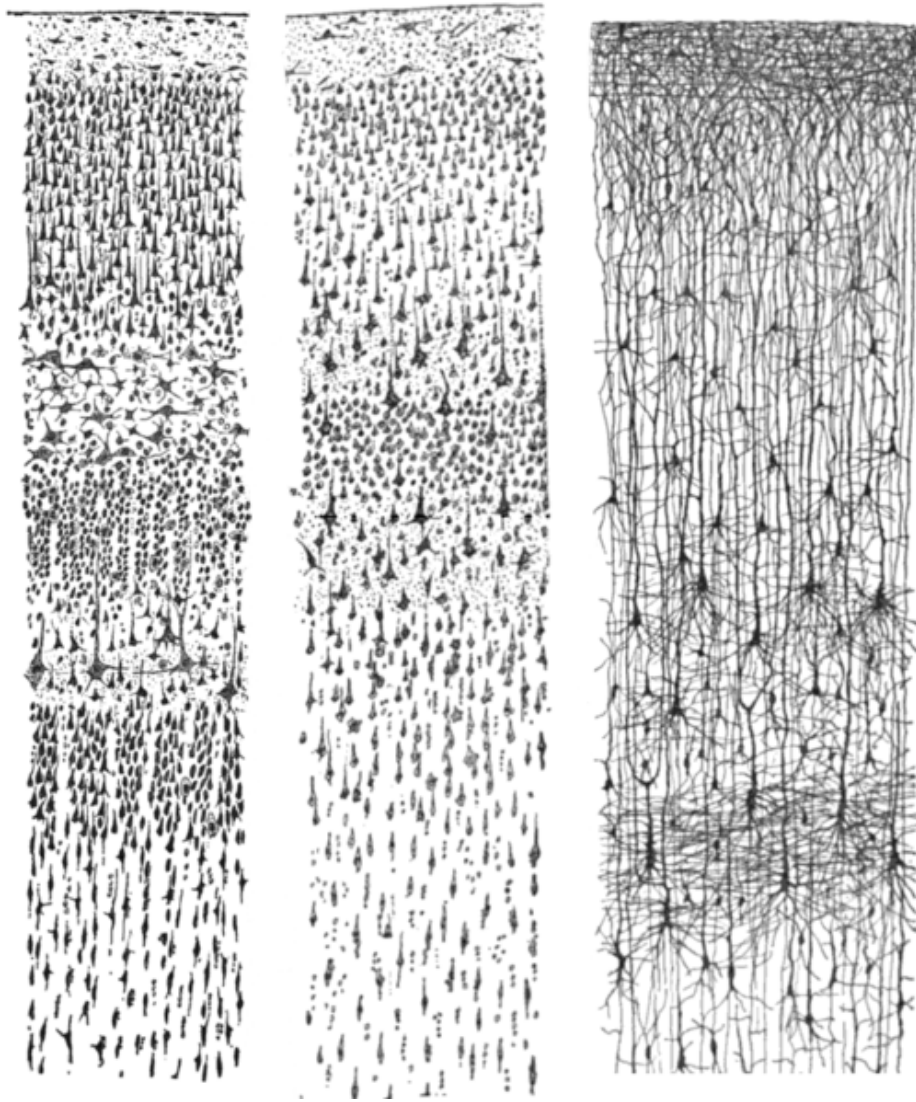
Quoting from Tully :

A novel application of multiple-network poroelastic theory (MPET) is proposed to investigate water transport in the cerebral environment. Specifically, MPET is modified to allow a detailed investigation of spatio-temporal transport of fluid between the cerebral blood, cerebrospinal fluid (CSF) and brain parenchyma across scales. This framework thus allows an exploration of hypotheses defining the initiation and progression of both acute and chronic hydrocephalus. Results show that a breakdown in the transport mechanisms between the arterial vascular network and interstitial space within the parenchyma may be a cause of accumulation of CSF in the ventricles. Specifically, there must be an increase in the compliance of the arteriole/capillary network, which may combine with a breakdown in the blood–CSF barrier to allow an increased flow from the arteriole/capillary blood to the CSF...

This mechanism accounts quite easily for all kinds of Ventriculomegaly, and normal and raised pressure hydrocephalus, as well as both communicating and non-communicating hydrocephalus.

Swedenborg is therefore correct in his statement that the brain produces CSF and this mixes with CSF produced (by the choroid plexi) in the ventricles.

Following Swedenborg's description further, the microtubules should pump small quantities of CSF throughout the body along nerve tracts, and according to his principle of *Discrete Degrees*, there may be a contraflow. This possibility is also borne out by Pollack's description of the water-pumping ability of microtubules. Simultaneously, the pores of the microtubules are the means by which the physical analogue of "soul" is distributed throughout the body (and again there will be some kind of contraflow).



Three drawings by Santiago Ramon y Cajal, taken from the book "Comparative study of the sensory areas of the human cortex", pages 314, 361, and 363. Left: Nissl-stained visual cortex of a human adult. Middle: Nissl-stained motor cortex of a human adult. Right: Golgi-stained cortex of a 1 1/2 month old infant. (approx 1901)
Image from WikiCommons

"Like the entomologist in search of colourful butterflies, my attention was drawn to the gardens of the grey matter, which contained cells with delicate and elegant forms, the mysterious butterflies of the soul, whose beating of wings may one day reveal to us the secrets of the mind" – Santiago Ramón y Cajal¹⁸

In fact, any disruption to flow of CSF tends to produce hydrocephalus, and the cilia (again, microtubules!) appear to be particularly important in this regard. Other recent studies have shown that normal motion of cilia is vital, and in fact disruption of the motion of *only* the cilia is capable of causing hydrocephalus¹⁹. Not only that, but the brain has an inherent pulsatility

18 Quoted by Mo Costandi *in* Neurons in the brain switch identity and re-route fibres : New findings could one day lead to gene therapies for stroke and spinal cord injuries. The Guardian Tuesday 26/Feb/2013. Online at <http://www.guardian.co.uk/science/neurophilosophy/2013/feb/26/neurons-in-the-brain-switch-identity>

19 Inés Ibañez-Tallon, Axel Pagenstecher, Manfred Fliegau, Heike Olbrich, Andreas Kispert, Uwe-Peter Ketelsen, Alison North, Nathaniel Heintz & Heymut Omran (2004) Dysfunction of axonemal dynein heavy chain Mdnah5 inhibits ependymal flow and reveals a novel mechanism for hydrocephalus formation.

that is particularly important during its formation, and this is caused and maintained by the action of cilia²⁰. And going back even further, the vertebrate blastocyst and embryo is unusual in that the developing cells rotate by 90° when undergoing mitosis, and this polarising action only appears to be capable of occurring if cilia are able to move normally²¹.

Returning to embryonic development, the role of microtubules is fundamental to all processes that divide and form the embryo. Pollack clearly describes how the fluid pumping properties of microtubules elegantly describe and explain the almost miraculous way in which microtubules appear to coordinate cell mitosis in the division of DNA. I have wondered about this extraordinary alignment and dance of microtubules for some time, and this is one particular element that to me is especially persuasive that the phase change of water as a basic cellular process is “on the money”. It has recently been shown²² that extracellular fluid flow – both due to the flow induced by cilia and the pulsatile forces of the mother's heartbeat in the vascular bed of the placenta - drive many of the formative movements of the developing embryo. The total process is less clear when it comes to the remainder of the organelles. Most textbooks focus on DNA replication, forgetting that *all* cell components have to be duplicated to produce two viable cells. Golgi apparatus, mitochondria, nucleus, membranes, centriole, cytoskeleton – etc – all have to be duplicated. This complete process is still only understood in a very sketchy manner. A recent review²³ presented the evidence available to date, and the orchestrated dance of the DNA appears to be very similar to the dance performed by the other cell organelles, and there is a complex patterns of communication dominated by signals between and from the nucleus and centrosome.

Human Molecular Genetics, Vol. 13, No. 18 pp2133–2141 doi:10.1093/hmg/ddh219

- 20 Blaise Yvert, Claire Mazzocco, Sébastien Joucla, Adeline Langla, & Pierre Meyrand (2011) Artificial CSF Motion Ensures Rhythmic Activity in the Developing CNS Ex Vivo: A Mechanical Source of Rhythmogenesis? *The Journal of Neuroscience*, 15 June 2011, 31(24): 8832-8840; doi: 10.1523/JNEUROSCI.1354-11.2011
- 21 Zaman Mirzadeh, Young-Goo Han, Mario Soriano-Navarro, Jose Manuel García-Verdugo, and Arturo Alvarez-Buylla (2010) Cilia Organize Ependymal Planar Polarity. *The Journal of Neuroscience*, 17 February 30(7): 2600-2610; doi: 10.1523/JNEUROSCI.3744-09.2010
- 22 Jonathan B. Freund, Jacky G. Goetz, Kent L. Hill & Julien Vermot (2012) Review : Fluid flows and forces in development: functions, features and biophysical principles. *Development* 139, 1229-1245 (2012) doi:10.1242/dev.073593
- 23 Yuuta Imoto, Yamato Yoshida, Fumi Yagisawa, Haruko Kuroiwa & Tsuneyoshi Kuroiwa (2011) The cell cycle, including the mitotic cycle and organelle division cycles, as revealed by cytological observations. *J Electron Microsc (Tokyo)* (2011) 60 (suppl 1): S117-S136. doi: 10.1093/jmicro/dfr034

The centrosome also appears central stage in Guenter Albrecht-Buehler's description of cell intelligence²⁴. Having studied cells for over 30 years, he points out that cells move in a way that indicates they have an intelligence – but also they are composed of organelles that also act in an intelligent manner²⁵.

We may be seeing here the first glimpse that intelligence is a fractal property: Intelligent ecologies contain intelligent populations, which contain intelligent organisms, which contain intelligent cells, which contain intelligent compartments, which contain...and so forth.

So it is something of a chicken and egg situation – do fluids create the movement that organises cells and cell division? Or do cells and cell organelles (and even single microtubules) organise themselves so that they can direct fluids so that the cell divides as it should? This is also reminiscent of the aphorism used by AT Still...

Form follows function, function follows form

Which comes first? Swedenborg would say that it is function – in the sense that every part of life reflects the workings and purpose of its Creator – that determines the form *and functioning* of all life, from the tiniest bit of cytoskeleton up to a pod of blue whales.

In summary, we have come something of a full circle, and at the same time have a clear arrow of causality apparent in all of this evidence. From Swedenborg's statement that the “Spirituous force” travels through the body in the nerves; to Penrose and Hameroff's statement that it is likely the microtubules that mediate what we call consciousness; to Pollack's description of the way that microtubules/cilia create movement in water by a phase-change pumping action (and how this controls cell mitosis), through to Freund et al's (and Ingber's and Blechschmidt's) description of the fluid forces that drive embryogenesis.

Well- at least it's a nice theory.

24 <http://www.basic.northwestern.edu/g-buehler/FRAME.HTM>

25 Albrecht-Buehler, G. (1980) The autonomous movements of cytoplasmic fragments. Proc. Natl. Acad. Sci. U.S.A. 77: pp6639-6644

5. Swedenborg, Pollack and the Craniosacral Rhythms

In terms of microtubules in cilia, the flow of water they induce and the ciliary motion follows Newton's third law of motion :

For every action there is an equal and opposite reaction

So the water is forced along the outside of the microtubule, then jets against the static water in the ventricle, and as the mass of water moves in one direction, the microtubule/cilia is forced in the opposite direction against the mechanical leverage of the stiffness of the cilia and the ciliary root in the ependymal cell. However, in the case of this third law that is particularly relevant to biological processes, the thesis also has an antithesis, and it could (rather less elegantly) be stated that

For every lack of reaction there is a concomitant degradation of the actioning force

Thus, the ability of the fluid to be moved and the ability of the cilia to mechanically respond are counter-forces that may affect the cascading ionic process that drives the pulse of fluid water through the structured water coating of the microtubule. We therefore always have two distinct directions in which pathology may arise and in which a treatment may intervene. In fact, these two directions are in some ways caricatures of the two directions taken by AT Still and JM Littlejohn in the early years of Osteopathy. We can aim to release and strengthen the process itself, or we can almost ignore it completely and simply remove obstructions to its functioning – free off whatever it is pushing against. This, according to Swedenborg, applies even on a spiritual level. Spirit enters the body, bringing both motive energy/life force and information/a pattern of health. So the most obvious principle might be to assist that force to enter. However, if, for instance, the rhythmic influx of this spirituous energy is bound by a physical immobility of a set of sutures or tissues, then removing even a small part of these obstacles would also be useful. In short can I see no particular reason for an exclusive generic preference between fluid techniques and so-called biomechanical ones, other than the fact that the higher forces are capable of bringing health whereas the more physical one are only capable of stopping it. So although there is a natural order from higher to lower, one can maybe place a ratio on the relevant directions of maximum impact for an individual. If there is already a natural orientation towards vital force, then it may be that what is not working requires more physical assistance. If there is insufficient vital force, then that would tend to take priority over physical, but only so far as the physical was capable of responding to whatever vital force is available. These things are impossible to quantify, and the intelligence we are dealing with is somewhat beyond these rather contrived descriptions.

It is maybe useful to use Yoga as an analogy for this. The Yogi has a spiritual aspiration. Physical movements and postures are used to strive towards this spiritual goal. The postures are intended to bring about an alignment in a bottom-up direction that will facilitate the spiritual aspiration. Eventually both meet somewhere in the middle, and the body becomes fully flexible and capable of entering each of these postures with ease because it is full of vital force. Has the work with the body and posture been 1% of the important part of journey? Or 5, 10, 50 or even 90% of it? For each person this will be different.

If we examine the cranial rhythms with some honesty rather than expectation, then several important observations arise that may tell us something of their mechanism and what we are working with. In particular, there are “normal” phenomena in which the rhythms are moving “as they should” and there are odd abnormal phenomena which contradict the usual mechanistic and even conceptual models that are used to describe them. Just as in science, one can choose to not allow these to even enter the radar, or one can ignore them as being irrelevant, or one can consider that they might have something important to say. Taking the latter position...

- Although the CRI usually involves the occiput and sacrum moving in the same direction, sometimes one is moving and the other is not, sometimes they move in opposite directions.
- Sometimes a counter-rhythm is detectable moving simultaneously in the opposite direction to the main rhythm, and at more or less the same speed.
- Sometimes several rhythms are detectable simultaneously – i.e. both the CRI and the mid-tide.
- The temporal bones are capable of contralateral motion – in fact this is quite a common phenomenon.

The *experience* of sacral motion of the CRI is not an upward pull on the sacrum (as would be the case if it were driven by a superior contraction the dura) but rather an anteropodad thrust of the body of the sacrum.

There have been several attempts to attribute the CSR to literal fluid forces. This was recognised by Sutherland and Magoun as being an incorrect interpretation, possibly based on exactly the same observations as have been made above. To put the argument in a nutshell, if fluid literally drives any mechanism then it is impossible that any part of the mechanism should move contrary to or asynchronously with any other part. So CSF flow or pressure or venous blood pressure as *driving* mechanisms for any rhythm are not credible contenders.

In fact, all attempts so far to explain the cranial rhythms have stumbled on one huge concrete block, otherwise known as Occam's Razor. The temptation has always been to ascribe these phenomena to just one mechanism. Swedenborg on the other hand recognised that there are many mechanisms in the body that are usually synchronous (probably because that is a more efficient way for the body to work), but which inhabit different modes of operation and apply themselves through different media and which are *not necessarily* synchronous.

So, taking the CRI, it would seem that the sacrum and vault may be driven by a common mechanism, and may also be driven by two mechanisms that can be contiguous or decoupled from each other. This is somehow suggestive that the parasympathetic nervous system may have a part to play in this level of cranial motion. The traditional description of the sacrum being pulled up by the dural connection to the anterior surface of the 2nd segment of the sacral canal is at odds with *both* the experiential motion of the sacrum in flexion *and* the ability of the sacrum to decouple from the CRI in the vault. The quality of motion of the sacrum is (to

me, personally) more evocative of the deep midline fascia and the fascial bands running anterior and posterior to the vertebrae. However, there is also no doubt that sometimes, some of this motion also travels through into the spinal dura. This inherent ambiguity/ ambivalence is typical of the workings of *Discrete Degrees*.

The Midtide phenomena are far more universal, but can still undergo significant L-R fluctuations and oscillations, which again is somewhat suggestive of a neurological basis. The motor of the third ventricle would very comfortably fit with the motion of microtubules in the ependymal cilia, and its persistence as a palpable phenomenon beyond the skin would suggest that we may be talking about “something” (also) happening inside the microtubules rather than a direct causality from the fluid motion outside them. However, as has been described above, one goes hand in hand with the other, and it is not inconceivable that the flow of conscious phenomena in cilia has some bearing on their mechanical activity.

Clearly, there is no end to the possible speculation. But some of the mutual relationships described above and the multiplicity of driving mechanisms suggest that it could be some time before any clear causal physiological line is drawn more specific than those described by Emanuel Swedenborg, some 250 years ago.