# Sutures and Cranial Mobility

By Thomas Rasmussen, PhD, MSc, CST-D

One of the main questions in CST relates to the controversy of cranial bone motion in relation to suture closure or not in humans. More recently many studies done in forensic medicine with very high-resolution modern scanners, and the use of cellular and molecular biology have created major advances in the understanding of sutures.

Cranial sutures have a wide range of functions, originating from embryological different tissues with diverse properties. Sutures are of major importance for our cranial growth and brain development, as the major site for interstitial growth of the cranial bones. Sutures allows for skull movement for ease of the passage to the birth canal. Partly fused or fused sutures provide protection for the brain. Sutures are also reported to be essential for shock absorption, and for the redistribution of strain across the skull. The strain in relation to sutures may both be identified in the developmental process and daily life.

Sutures are complex and of different developmental origin, thus coming from different tissues, and conclusions drawn from one suture may not apply for other sutures of the skull.

Different joint types of sutures can be identified in cross-section (see figure 1). The growing suture starts out as an end-to-end joint as in figure 1A with Sharpey's fibers (type 1 collagen) creating local connections between the growing bones in a unique pattern determined by pressure and strain at the local site, forming different local suture joint morphologies (figure 1). As an example, 10 different sagittal sutures from human skulls are shown in figure 1. Differences in suture morphology is not only seen between persons, but also different suture morphologies can be observed within the same person's sagittal suture. The pattern of interdigitation and corrugation is believed to result from pressure and strain patterns in the developing suture, and that each suture is unique at a local level.


Figure 1. Left. Different forming local suture joint morphologies formed by pressure and strain. Right. Ten different sagittal sutures from human skulls.

**Fascia-Suture Relations**

Sutures in their open stage can be viewed as consisting of two growing bone edges on either side of the suture with a mesenchymal tissue in the middle, underlined by the dura mater and overlined by the pericranium (bone fascia) (see figure 2 below).

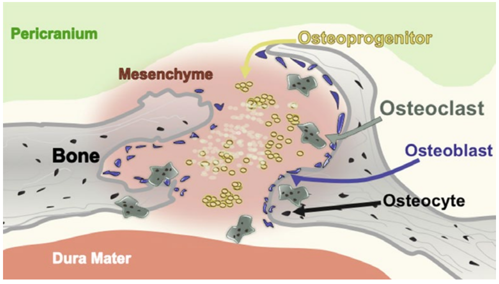



Figure 2. Suture with two growing bone edges on either side of the suture with a mesenchymal tissue in the middle, underlined by the dura mater and overlined by the pericranium.
The dura mater plays a role in suture openness and degree of closure, and factors produced by the dura mater can communicate that a suture stays open or close. In addition to being involved in the suture process, the dura mater develops close attachments in general to the cranial bones. The periosteal layer of dura mater has hair-like structures on the surface of the exposed dura mater surface connecting the dura mater to the skull bones. The connecting fibers are Sharpey's fibers, the collagen type 1 fiber, that also makes connections between sutures and anchors your teeth to the bone. The intimate relation between the dura mater and the suture area creates a stronger attachment of dura mater in suture areas.

The outer layer of the suture is another fascia structure important for the skull, the pericranium, a strong bonding fascia to suture/bone. The micro morphology of the suture has revealed a zonal organization of the pericranium. Three zones can be identified, an inner zone that mainly consists of osteoclasts with a minor content of fibroblasts and collagen fibrils, the inner zone is in contact with the surface of the bone. The middle zone of the pericranium has a major volume of matrix (no cells), collagen and fibroblasts and vascular structures in equal amounts. The third outer zone consists mainly of fibroblast and collagen fibrils with minor matrix. Thus, the pericranium has a transition from outer fascia to inner suture/bone environment reflected in the cellular composition.

***Importantly, the pericranium fascia has a stronger attachment to sutures. Tensions and strain in the outer pericranium will focus more on the suture's area, as the inner dura mater tensions will focus in the suture area from inside of the skull.***

***Restriction patterns in the sutures likely reflect a combination of fascial, sutural/interosseous tension.***

**The Openness and Closure of Sutures**

The sagittal suture is one of the most studied sutures of the cranial vault and is used here as an example of sutures that follow a growth and ossification process called intramembranous ossification where bone develops directly from sheets of mesenchymal connective tissue (as in figure 1 above). The sagittal suture has a series of closure stages (see figure 2 below), from different stages of openness to complete closure (stage 6 in figure 2). The possible closure steps are not alone age-related, but factors such as stress, diet, immune system relations, and hormone changes (postmenopausal osteoporosis) are examples. The suture closure is variable, with a tendency to close at an earlier age in women, so a pop-apart experiment with sutures that disarticulate under pressure may occur in a 72 year old male with a quite open suture. In contrast, there are women with a nearly complete suture closure in their forties, although this is rare.

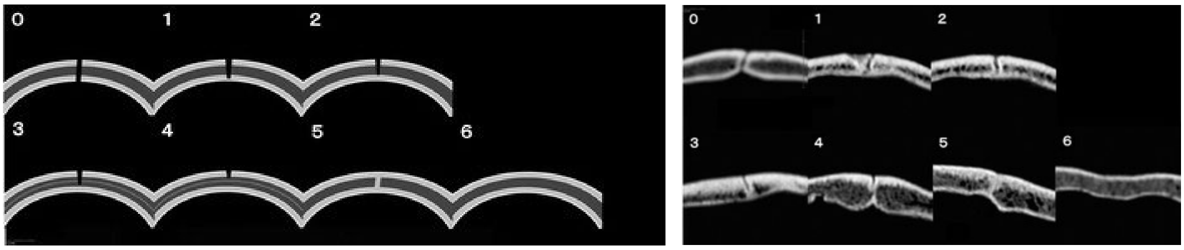



Figure 4.  Stages of sagittal suture closure.
Above is a schematic diagram of the seven stages closure. Below a real live three-dimensional scanning of the different stages. The seven stages of closure are; 0. Completely open. 1. Inner bone cortex beginning closed (<10%). 2. Inner bone cortex closed. 3. Less than half closed. 4. More than half closed. 5. Visible relic of the ossification process. 6. Complete closure without relic.

**Do Sutures of the Cranial Vault Stay Open or Close?**

The statement that there is increased suture closure with age is correct. The statement that there is a decreased in suture openness with age is also correct. A full fusion of the sagittal suture is quite rare in both women and men. More common is that the outer lamina in contact with the pericranium is open to some degree throughout life. In contrast, the inner lamina typically closes earlier in life.

**Cranial Base Sutures**

The cranial base is a structural platform for the CNS and is unique in function as a platform for the cranial vault and by shaping the craniofacial complex. The cranial base growth closely correlates with brain growth in a tightly regulated process. The cranial base is formed by endochondral ossification, different from the cranial vault sutures with intramembranous ossification, as described above.

There are two synchondroses, inter-sphenoid synchondrosis, which ossifies at age 2-3 years in humans, and spheno-occipital synchondrosis (SBS), which ossifies in relation to puberty in humans. The mean age for a completely fused SBS is 16 years in males and 15 years in females, regarding the earlier systemic hormone changes in females. The ossification processes of the spheno-occipital synchondrosis are today described with high-resolution scanning and at the single cell and molecular level.

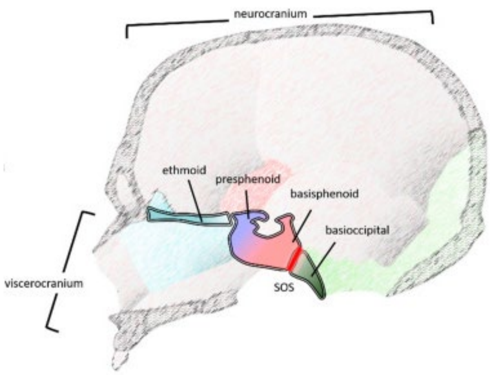



Figure 5.  Cranial Base

***Regarding Sutherland cranial base lesion patterns, in the* Craniosacral Therapy *textbook, page 10, Dr. Upledger's notes that restriction patterns are due to suture (interosseous) and fascia (dura mater) tension and not synchondrosis.***

Whereas some sutures like the spheno-occipital sutures close early (puberty), other sutures with a synchodrosis like the petro-occiptial synchondrosis, next to fully fused sphenoccipital and sphenopetrosal sutures, stay partly open throughout life. The occipitomastoid suture is open in most people > 90 years.

**What Gives Cranial Mobility?**

There are many factors to mention here that may keep a suture fully open, or semi-open with only the inner lamina fused, giving overall more mobility. Interestingly, the story of wet versus dry bone is quite true. Dead bone feels dry and hard; live bone feels wet and soft. Bone contains two types of water, bulk water and organized water, a layer between mineral crystallites. The existence of an organized water layer between bone crystallites and collagen gives bone unique properties and flexibility. The structured water layers in bone are in a space that includes citrate. Citrate is a 'spidery' molecule with four arms, all of which can bond easily to calcium – which bone is packed with. The citrate can hold the mineral crystals together simultaneously, preventing them from fusing while trapping the water, which allows for slippery movement and provides bone flexibility.

**Palpation of Suture Restrictions and Releases**

We palpate suture restrictions and release them. With the direction of energy, a suture releases as we feel it with our hands. The suture area is tightly bound to the fascia; from the inside, the dura mater has a stronger attachment to the suture area, and dura mater factors play a role in suture openness and closure. From the outside, the pericranium fascia is tightly connected to the suture area (see figure 1). In this way, the tighter suture areas we experience by hand are probably a fascia/suture restriction due to the more substantial relation between dura mater and pericranium at the suture area. The suture/fascia relation may explain the release signs and speed in many cases common for suture release and fascia release. In addition, different degrees of suture closure in combination with patterns of interosseous tension is probably also part of the hands-on experiences for some restrictions.

# The Craniosacral Rhythm

A central part of learning CranioSacral Therapy (CST) is to learn to palpate the craniosacral rhythm (CSR) and to distinguish the CSR from other rhythms, mainly the rhythm of the respiratory system. The CSR was named so by Dr. Upledger in his work, creating a foundation for what we know worldwide as CST.

In CST and osteopathy in the cranial field, different rhythms have been associated with the cranial field and theorized to be involved in human health from a wide range of perspectives. Many rhythms are studied today and are known to be fundamental to life and health. Rhythms are a rich source of palpatory information in facilitating a CST treatment. How is this knowledge integrated into understanding the relationship between what happens in a CST treatment and our understanding of human health

The CSR is a rhythm in the range of 4-8 cycles/minute (cpm), slightly slower than the respiratory rhythm, generally observed in the 9-20 cpm. However, these rhythms may overlap at their upper (CSR) and lower range (respiratory). Rhythms slower than the respiratory rhythm in the 4-8 cpm have been identified in research in different fields and given other names (see below). The main thing is that the 4-8 cpm rhythm has been firmly documented to be part of the array of rhythms expressed by the human body and that the CSR is a palpable rhythm. For more theory of rhythms and CSR, see below.

## Rhythms in Life and Health

On many levels, myriads of rhythmic processes occur at any time in the human body. Rhythms are a central part of life for the single cell and the unified human body. A rhythm is a movement in time, and we can have movements without life, but we cannot have life without movement. From conception to the last movement in our body, rhythms set the stage for our development, daily life, and health.

The human body exhibits a complex pattern of many rhythms that are the basis of life and interact in ways that, to a large extent, are unknown to science. New rhythms involved in our life processes and health are continuously being discovered.

We can imagine the spectrum of rhythms in the human body as a symphony that is being played, with each instrument playing its unique tones. Other instruments play their tones, and one instrument may lead while others follow, all creating harmonies in a landscape of different tones (rhythms), together creating a beautiful symphony. As we learn to palpate the respiratory rhythm, cardiac pulse, and CSR here in this class, we learn to tune in to some of the instruments played in the human body and get information about the instrument and how it is playing. The symphony played by the rhythms of life may be some of the most creative and beautiful music we can listen to.

# The Architecture of Rhythms in Life

The complexity of the array of rhythms in the human body makes it difficult for even the most advanced modeling systems to fully describe the most well-studied rhythms, such as the heart rate, respiratory breathing, and circadian rhythm. At the same time, no rhythm can be fully described in isolation.

A helpful model for describing complex systems was pioneered by the Nobel prize awarded Herbert Simon, formulating the theory of *The Architecture of Complexity* in 1962. The theory states that "*complex networks must take the form of hierarchy with unifying properties independent of their specific content*." Applying the theory to the complex rhythms of life, we can identify master rhythms by unifying different rhythms by entrainment, keeping other rhythms in a frame, or phase-lock a rhythm to a constant value or ratio.

***Unifying Master Rhythms.*** Humans need a multi-clock system to regulate the fast-changing environment and simultaneously have a long-term perspective to sustain life. Some of the most studied master rhythms are the cell cycle and the circadian rhythm. From the beginning of evolution, a cell is a unit for life, as is the cell cycle for the perturbation of life, making the rhythms of the cell fundamental for our life. On a whole-body level, all parts need to know the interaction and timing of all events. Even a cell needs to have a perception of time to time the metabolism and cell division. Just imagine the timing of cell division and differentiation in the developing embryo; all events happen with an incomprehensible timing of many rhythms at work.

The knowledge of circadian rhythm is central to getting a sense of the symphony of rhythms played in our bodies. The massive impact of the circadian rhythm is shown as 50% of our genes change their expression during a circadian cycle. The circadian cycle is regulated by oscillating neurons in the hypothalamus, a master unifying center for the function of our life. A group of oscillating neurons keeps this cycle entrained independent of the light/dark cycle to a range for humans of 21 to 29 hours. With a group of light-sensitive oscillating neurons, the 24-hour cycles are created. In addition to the sun giving a 24-hour cycle of light and dark, the moon provides a semi-diurnal 12-hour rhythm, making a high and low tide twice a day. The influence on water and solid matter is massive, creating high-low tides in oceans up to 40 feet and compressing and decompressing mountains. The circadian cycle is synchronized with or entrained with the 12-hour lunar cycle phases, which also affects our sleep pattern.

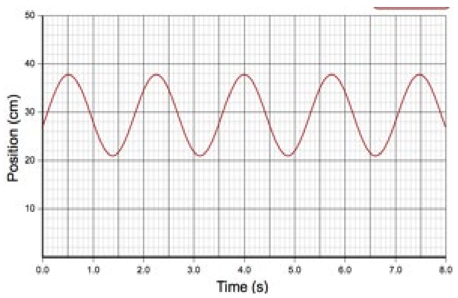
***Autonomous rhythms.*** Autonomous rhythms are subdivisions in the life architecture that allow part of the system to free-run, receive entrainment, and make compensations from the environment. Examples of autonomous rhythms are the regulation of heart rate and respiratory breathing, both important for survival, with autonomous systems for the generation of rhythms that can be closely regulated according to the current needs. In the heart, there are autorhythmic cells (pacemaker) that, without extrinsic influence from neural or hormonal effects, keeps a beating around 100/min. Respiratory breathing has oscillating neurons in the brainstem that are not using a homogenous group of oscillating cells like the hearth pacemaker. Still, a system of at least two oscillating groups of neurons to keep breathing on a minute-to-minute balance.

# How the Body Creates Rhythms

How do cells and biological systems perceive time? To perceive time, a clock is needed; clocks are rhythms like the rhythms of the sun and moon from where we have created our chronological time. All clocks, from the lifespan of a human to the process inside a cell, have an internal clockwork that, throughout life, responds, regulates, and communicates our life process.

A rhythm is a wave moving in time, and a wave is an oscillation, so the creator of a rhythm is an oscillator. As described above, autonomous rhythms such as the heart rate and respiratory breathing use oscillation at the single cell level that are united to form groups of cells that can oscillate a rhythm, often in a central organizing place of the body as the heart and the brainstem.
The circadian rhythm is a central master rhythm located in one of our body's most central organizing centers, the hypothalamus. The hypothalamus "sits" on the midline of the sphenoid bone above the sella turcica, the deepening of the sphenoid bone holding space for the pituitary gland. In the hypothalamus, a bilateral cluster at the left and right side of the third ventricle called the suprachiasmatic nucleus contains around 20,000 nerve cells with coordinated rhythmic excitability creating the circadian rhythm. A group of oscillating neurons are sensitive to light and fine-tune the rhythm of the day/night cycle, including seasonal changes in the light period.

What creates and coordinates the rhythmic excitability of the neuron? The creation of the oscillation takes place on the molecular level at the fundament for life, *the central dogma* of biology, that states that the template for life DNA is transcribed into RNA that is translated into protein. The oscillation is created by a transcriptional and translational feedback loop. The neuronal oscillation created by the feedback loop expresses a gene on the DNA level; the resulting protein changes the excitability of the neuron, and the protein blocks its own gene expression and initiates its own degradation. As the protein is degraded, the block of the gene expression is removed, and a new cycle occurs.



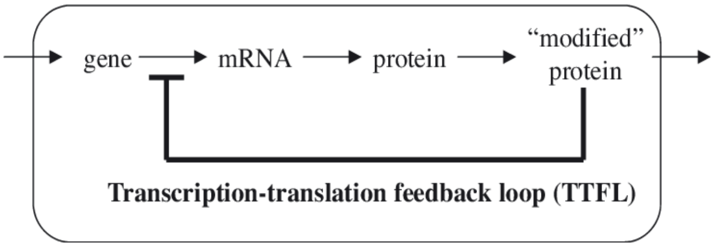




Figure 8. Left oscillation from neurons. Transcription-translation feedback loop.

## Harmonics, Communication, and Physiology

Rhythms may be related in harmonics as a series of natural frequencies that can be identified as subdivisions or master communication systems for the body. When an oscillator creates a rhythm in the body, it may result in a series of natural rhythms. A natural rhythm is where a standing wave pattern is created and is called a harmonic frequency. At all other frequencies, the wave pattern from the oscillator is irregular and non-repeating. The original wave produced by the oscillator is called the 1st harmonic or the fundamental frequency. The following standing wave can be created at one-half the wavelength of the first harmonic, the third harmonic is one-third the wavelength of the first harmonic, and so on. The frequency of the rhythm is related by whole number ratios, between first and second harmonic 2:1, second and third 3:2, and so on. Each oscillator can thus generate a set of natural frequencies with a standing wave pattern. All waves in a harmonic system travel with the same speed, as the rate only depends on the media the wave travels in, here, our body. So, palpating rhythms from the same harmonic series will all have the same speed but different frequencies.

Cells in our body have different rhythms; as described above, the circadian 24-hour cycle involves a prominent cycling rhythm in gene expression. In addition, cells show 12-hour, 8-hour, and 4-hour rhythms, the second, third, and sixth subharmonic of the circadian rhythm. The 12-hour cycle is also the rhythm of the lunar cycle, and the circadian and lunar seems to communicate as two master rhythms of the body. For example, the 12-hour cycle is seen in the gene expression of liver cells giving a 12-hour activity cycling. In Chinese medicine, a classical experiential concept is the organ clock with a high and low energy peak at 12-hour high and down in a 24-hour cycle, now supported by modern experimental science with the 12-hour gene expression cycling in organs. The rhythmic process of cells and cell organelles are coordinated, so that cell division and metabolism are coordinated by master clocks of circadian and diurnal rhythmic systems. In evolution, our life-giving rhythms have been developed by the rhythm of the sun and moon using the fundamental *central dogma* architecture of rhythms.

***Synchrony, coherence, and homeostasis.*** Homeostasis is a state of steady physiological equilibrium, essential for maintenance and adaptation to life. Homeostasis is based on the coordinated balance among tissues and organs to ensure systemic control of physiology.

Life and physiology have evolved as the Earth rotates around its axis, establishing light-dark as a perpetual cycle. Our homeostasis and health are connected to the coherence of natural rhythms.

In this context, the rhythms form the necessary communication using entrainment, phase-locking, and coherence in the hierarchy network of rhythms. The circadian and lunar rhythms represent the quintessential examples of homeostatic control. Homeostatic failure is the basis of many diseases, and rhythm malfunctioning as loss of circadian and lunar coherence often imposed in modern society disrupts coordination among rhythms. It has been linked to various diseases, such as cardiovascular disorders, metabolic perturbations, neurological disorders, and increased cancer risk. Thus, uncovering the physiological circuits whereby biological rhythms achieve coherence will inform challenges and opportunities in human health.

# Theories of the Craniosacral Rhythm

***History of Rhythms in CST.*** As part of the foundation of osteopathy in the cranial field, its creator William Garner Sutherland formulated an idea that in complex organisms such as humans, there must be a mechanism for the whole system regulation, from the central down to the single cellular respiration. Sutherland named his postulated mechanism The Primary Respiratory Mechanism (PRM). The term primary respiration was used to highlight that PRM respiration precedes the respiratory breathing mechanism. Sutherland believed that the origin of the PRM was in the brainstem in the area of the 4th ventricle. Sutherland's idea of a PRM for whole system regulation is similar to the scientific understanding of master rhythms regulating and unifying the homeostasis of our physiology. The main question is whether there is a master PRM in addition to or unifying with the master rhythms of circadian, lunar, and cell cycles?

***The Pressurestat Model.*** At the time of founding CST, Dr. Upledger and others had suggested different possible sources/models for the generation of CSR. A hydraulic pressure theory suggesting rhythmic variations in the production of CSF by the choroid plexus was proposed by Magoun. Upledger and Vredvoogd expanded the choroid plexus hypothesis by adding neurological and mechanical mechanisms and formulated a Pressurestat Model.

Upledger's Pressurestat Model describes a semi-closed hydraulic system contained within the dura mater which envelops the brain and the spinal cord. Within this system the production, circulation, and reabsorption of cerebrospinal fluid (CSF) was hypothesized to take place. The production and reabsorption of CSF within the dura mater was to produce a continuous rise and fall of fluid pressure within the craniosacral system, generating the CSR as an expansion and contraction we can palpate. The Pressurestat Model was based on the bulk flow model of CSF that is widely accepted and found in most anatomy book, and Upledger's own preliminary research on a neuromechanism for the regulation of CSF production. The Pressurestat Model has served as a model for teaching CST for many years and served its purpose.

Science is again and again amazed with Mother Nature, who keeps surprising us with a complexity and brilliance that we learn from. Systems of rhythms regulating our health at a profound level, the many ways CSF is moved in the CNS to allow nourishment, cleaning, and communication, has shown that the simple bulk flow of CSF and regulating system in the Pressurestat Model, is today replaced by a growing understanding of rhythms and CSF circulation and function.

***Rhythms in the Cranial Field and Heart Rate Variability (HRV).*** In CST and osteopathy in the cranial field, different rhythms have been associated with the cranial field and theorized to be involved in human health from a wide range of perspectives. Different rhythms have been identified under other names, and a link between the various rhythms as a harmonic system has been hypothesized. Recently 4 rhythms of the movement were identified on the head and everywhere on the body. Rates are 6 cpm (main range 5-7 with outliers 4 – 8cpm), 2 cpm, 0.6 cpm, and very slow 0.1 cpm area. All the identified rhythms are in the frequency areas observed in HRV four frequency bands with oscillations into ultra-low-frequency (ULF), very-low-frequency (VLF), low-frequency (LF), and high-frequency (HF) bands classified in the HRV.

The HF band corresponds to the effects of respiratory breathing, and the LF band contains the impact from the 6 cpm movements. The slower LF and VLF frequencies are much less known, but interestingly the slower rhythms are strongly associated with human health.

***The Craniosacral Rhythm.*** The highest frequent regular rhythm is called the Craniosacral Rhythm (CSR); other names used are the Cranial Rhythmic Index (CRI) and Short Tide. Different research fields have also studied a 6 cpm rhythm, as the baroreceptor reflex is one of the body's homeostatic mechanisms to maintain blood pressure levels at a narrow range. The baroreceptors rely on specialized neurons located in a strategic place and, from there, send information to the brainstem. The 6 cpm rhythm can be measured concerning the movement of blood. The 6 cpm rhythm is part of the Heart Rate Variability and is measured by international standards today. HRV is the fluctuation in the time intervals between adjacent heartbeats and is a popular measure related to rhythms to health. In addition, smooth muscle in the walls of microcirculation exhibits "spontaneous" oscillation of 6 cpm. The 6 cpm rhythm can be palpated and measured as a movement everywhere on the head and body. The 6 cpm rhythm has been firmly documented to be part of the array of rhythms expressed by the human body.

The origin of the CSR is unknown today, and both a heart/baroreceptor reflex model and a model with a centralized origin in the brainstem have been suggested. In favor of a central origin is the identification of a group of 6 cpm oscillating neurons in the brainstem and that the 6 cpm rhythm is still observed when the baroreflex mechanism is blocked. The observation that the 6 cpm rhythm is stable with a stable frequency variation (4-8 cpm) among humans, and narrow range variation in the individual, suggests a centrally generated autonomous rhythm originating in the brainstem. In addition, to a model of autonomous rhythm originating in the brainstem that communicates with a master rhythm, the possibility that the rhythm is a harmonic of one of the master rhythms cannot be excluded.

***Low-frequency rhythms.*** There are many low-frequency rhythms of more unknown origin; nevertheless, these rhythms are often strongly associated with our health. In the cranial field, a rhythm of 2 cpm, often associated with the mid-tide, has been identified as a palpatory and measured rhythm. A few studies have postulated a neuron oscillator in the spinal cord with the same frequency range as the mid-tide rhythm. At a lower frequency, a 0.6 cpm rhythm has been measured and is often named the long tide. A new rhythm related to the cranial field was measured with an even lower frequency of 0.1 cpm. The 0.1 cpm rhythm is in the frequency area of the ULF band of the HRV. As described above, the cellular process is linked to the master rhythms of the circadian, lunar, and cell cycles, creating a unifying hierarchy with communicating strategies. Low frequent rhythms may contain rhythms that are harmonic to the master rhythms, be autonomous rhythms, or include unknown master rhythms.

***Primary Respiratory Mechanism.*** Is there a mechanism in the human body for a whole system regulation, from the central down to the single cellular respiration, a PRM postulated by Sutherland? One such mechanism has been intensively studied, the 24/12-hour interplay of the circadian and lunar master rhythms having a unifying regulation of autonomous subdivisions rhythms down to the level of subcellular processes, thus having primary regulation of known life processes.

A central question in the cranial field has been whether a master rhythm, a PRM similar to the other master rhythms, has a central organizing function in human physiology and at the core of our health. In search of a possible PRM concerning the cranial field, the ultra-slow 0.1 cpm rhythm was identified. The 0.1 rhythm was the slowest rhythm observed, expressed as a head and body movement. As a rhythm of the lowest frequency, this is a fundamental frequency or 1st harmonic. Most interesting, the 0.1 cpm rhythm was identified in the respiratory breathing as cycling in the breathing pattern, suggesting unifying properties above the level of autonomous respiratory breathing. The 0.1 cpm rhythm is a possible candidate for a unifying rhythm, with the higher frequent rhythms as harmonic or autonomous subdivisions rhythms in the system.

Most importantly, the 4 rhythms are all expressed as a movement of the entire head and body, explaining the experiential discovery of the rhythms before experimental measurements were possible.

# Why Palpate the Craniosacral Rhythm?

Rhythms are the fundamental part of life and health, and their coordinated expression is the fundamental basis for homeostasis and health. The powerful biological, regulatory processes at work that we can detect with our hands as palpable oscillations and rhythms are a rich source of palpatory information in facilitating a CST treatment.

The primary source of these rhythms seems to be located in the hypothalamus, brain stem, and spinal cord, all at the core of the craniosacral system and concerning the deeper health within our bodies.

In Upledger CranioSacral Therapy, we will use the Craniosacral Rhythm, the 6 cpm rhythm. This rhythm has the highest frequency giving instant feedback and is invaluable in identifying physical restrictions and autonomous nervous system balance. In addition, it is, for most people, the easiest of the rhythms to palpate. In later classes, after SomatoEmotional Release 1, we will open our awareness to the lower frequency rhythms.

Science is still revealing more daily about the workings of our highly complex physiological and neurological functions. But we know that CST is a powerful and effective tool for assisting the Body/Mind/Spirit in rediscovering and maintaining higher and more regulated states of coherent living with our outer and inner environment.

# Cerebrospinal Fluid

The knowledge of Cerebrospinal Fluid (CSF) and its movements is changing rapidly in these years. The different mechanisms behind many unique patterns of CSF movements are continuously discovered. Modern research on human health and, thereby, the CNS and the related systems to CSF, is taking place at a speed that was difficult to imagine even ten years ago.

Just few weeks ago a fourth meningeal layer/membrane was reported. Another possible aspect of control and flow of CSF around the brain is being discovered. The described fourth membrane SLYM (figure 9) adds to a long list of the complex role played by CSF.

A simple model of CSF fluctuations as an explanation for the craniosacral rhythm that we palpate with our hands has been updated today due to new science and measuring capabilities. Therefore the model of CSF movement postulated in the Pressurestat Model needs to be updated while the relation to health effects of CST in relation the CSF movements continues to have a long list of positive outcomes.

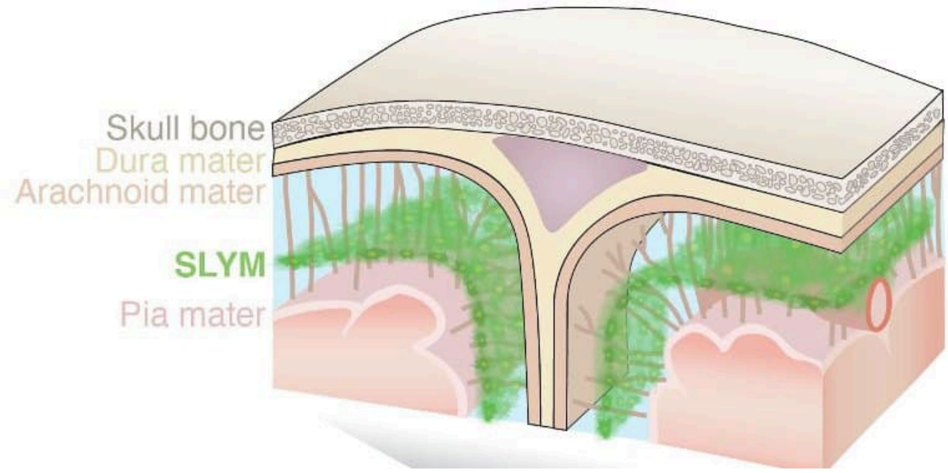



Figure 9. The fourth membrane SLYM.

Movement of CSF involves many different mechanisms with both general and local acting parts. The use of cilia on the ependymal cells to make local movements of CSF in the third ventricle is today well-studied. The rotational local movement of CSF can today be monitored by advanced scanning techniques (Figure 10).

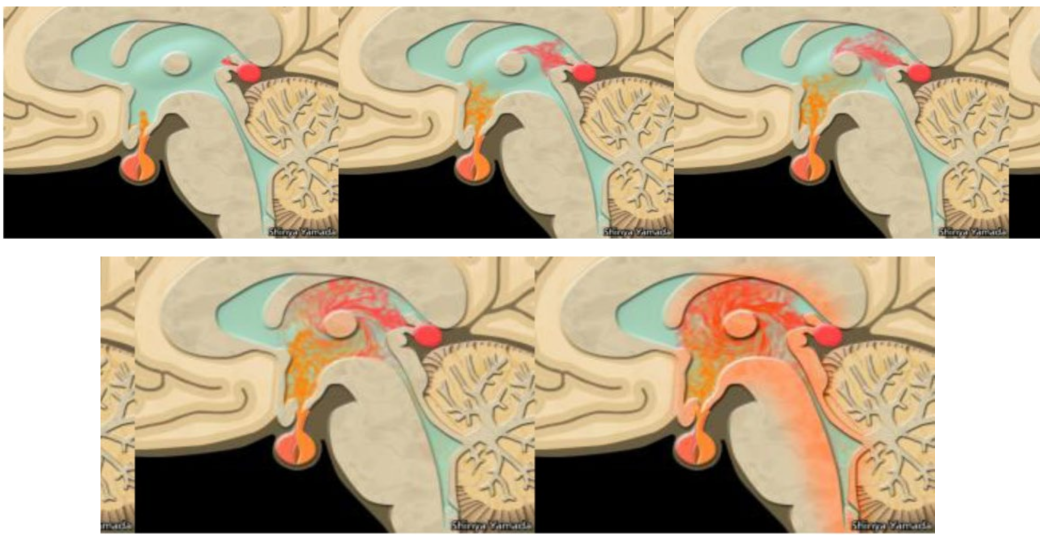


Figure 10. Molecular marking of liquid areas in the third ventricle near hypothalamus area (orange) and pineal gland area (red). The local directing of liquids in the third ventricle is illustrated.
Another example of CSF movement is the different rhythmic movements in the fourth ventricle at different states of consciousness (Figure 11). The pulsation in CSF in the fourth ventricle is created by the respiratory breathing during a state of being awake. The pulsation in CSF in the fourth ventricle during deep sleep is with 2-3 cycles/min, signified by a state with a slow delta brain wave of 2-3 cycles/min, that simultaneously opens the glymphatic system.

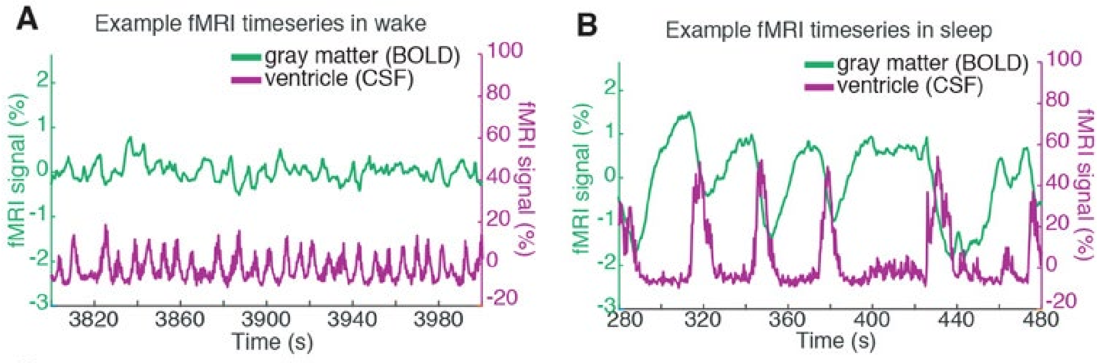



Figure 11. CSF rhythmic movements in the fourth ventricle during a state of awake (A) and in deep sleep (B).