I. Objectives; The attendee will:
   A. Recognize the relationship between the 0.08-0.2 Hz low-frequency oscillations in human physiology and Cranial Osteopathy.
   B. Understand that cranial palpation alone may be used as a sham intervention for research into Cranial Osteopathy.
   C. Observe the impact of various types of cranial manipulation upon the 0.08-0.2 Hz low-frequency oscillations.
   D. Consider new normative values for the rate of the cranial rhythmic impulse.

II. Introduction:
The information contained in this presentation is the result of collaboration between Nicette Sergueef, D.O.(France), Thomas Glonek, Ph.D. and myself. The referenced protocols that follow could not have been implemented and completed without their contributions. I am extremely grateful to them. K.E.N.

A. William Garner Sutherland, D.O., D.Sc.(Hon)
   1. First proposed the Primary Respiratory Mechanism (PRM) in 1939. Sutherland WG. (Ref 1)
   2. The term Cranial Rhythmic Impulse (CRI) was first used in 1961, when a rate of 10-14 cpm was reported. (Ref. 2)
   3. The subtlety of the PRM/CRI has generated controversy as to the validity of Cranial Osteopathy.
   4. Thus, it is appropriate to seek out quantifiable measures that will validate and provide understanding.

B. J. Martin Littlejohn, Ph.D., M.D., D.O., L.L.D. (Ref. 3)
   1. "In the therapeutic plane we are dealing with the nexus of spirit and body, and, therefore, with those vibrations or fluxions that lie at the foundation of the force called vital."
   2. In “the brain...we find certain rhythmical movements... corresponding, (1) with systole and diastole of the heart, (2) with inspiratory and expiratory changes, and (3) with vascular variations of vaso-motion.”
   3. “It is this that lies at the basis of all mechanical systems of healing, the setting up of increase or the checking of the vibratile impulses, the correction in the distribution of the normal vibrations sent out from the brain center of control and distributed by co-ordination from the different planes of center activity.”

C. Viola Frymann, D.O., F.A.A.O.
   1. The first successful attempt to measure the PRM/CRI by instrumentation.
   2. “The cranium is not only an elastic rather than a rigid container, but appears to at least at times involve itself in at least three distinct oscillatory motions.”
      a) “First an oscillation having the same period as the breathing of the subject.”
b) “Next, an oscillation having a period of five or six seconds, independent of the breathing cycle.”

c) “Lastly, a very slow cycle of from one to several minutes duration.”

3. “There is little doubt that the second of the distinct oscillations is the Sutherland wave, (C.R.I.) the jumping off point of Cranial Osteopathy.” (Ref. 4)

4. “The question to be considered next is whether a relation exists between rhythmic cellular function as described by Traube … and others and the rhythmic motion as recorded in the cranium.” (Ref. 5)

D. The Traube-Hering-Mayer (THM) oscillation

1. A complex low-frequency vibration.

2. It was originally recognized in blood pressure, and is a manifestation of baroreflex physiology.

3. It was first described by Ludwig Traube in 1865. (Ref. 6)

4. It was confirmed by Ewald Hering in 1869.

5. The slow component of the oscillation was described by Sigmund Mayer in 1876.

6. The component described by Traube and Hering has a frequency of 0.10-0.20 Hz (6-12 cpm) and is also demonstrable in:
   a) Bloodflow velocity
   b) Cerebrospinal fluid pressure (C waves)
   c) Muscle sympathetic tone
   d) R to R variability (respiratory sinus arrhythmia)

7. The THM oscillation was originally recorded as fluctuation of blood pressure using arterial canulation and more recently plethysmography.

8. We record the THM oscillation as fluctuation of blood flow velocity using the Transonic Laser-Doppler Monitor BLF21 Series. The laser-Doppler is linked to a PC for acquisition parameters and data processing.

9. These two closely related physiologic phenomena are concomitant manifestations of baroreflex physiology.

10. The THM oscillation is manifest in the bloodflow velocity time domain record as a complex wave form.

11. Time domain record, waves upon waves upon waves. (Figure 1)

12. Fourier transformation converts a time domain record into a frequency domain record. (Figure 2)

III. The First Protocol: The cranial rhythmic impulse related to the Traube-Hering-Mayer oscillation: Comparing laser-Doppler flowmetry and palpation. (Ref. 7) First, it was appropriate to establish a correlation between the palpated CRI and the 0.10-0.20 Hz oscillation.

A. Methods

1. The CRI, the palpable manifestation of the PRM, was monitored using a biparietal modification of the vault hold.
2. This hand position allowed the examiner to observe the CRI with minimal distortion from underlying cranial dysfunctional patterns.
3. Twelve subjects participated in the study.
4. An adhesive Doppler probe was placed onto the left earlobe of each subject.
5. Each subject lay quietly on the examination table for approximately 5 minutes prior to the onset of data acquisition.
6. An equilibration-period record was then recorded.
7. A continuous, unbroken palpation record of approximately 5 minutes duration was recorded.
8. Examples of two different subjects, with fast and slow waves. (Figure 3)
10. Note: frequency modulation correlation between THM and event markers
11. Similar frequency modulation was identified by Lockwood and Degenhardt in their analysis of Frymann's 1971 data. (Ref. 8)

B. Results
1. Of the 12 subjects that participated in the study, 11 provided high-quality data for analysis.
2. For the twelfth subject, the signal-to-noise observed in the laser-Doppler (time-domain) output was too low for precise quantitative measurement.
3. All features observed for the 11 subjects, however, were present in the Fourier transform (frequency-domain) record of the twelfth.
4. Recorded frequencies for maxima and minima were distributed uniformly among the 11 test records (N, 613; Mean, 56; Range, 39-77).
5. There were 166 flexion events and 162 extension events (N, 328) associated equally between Maxima (N = 164) and Minima (N = 164).
6. There was no correlation between the occurrence of a maximum or minimum and the palpation of a flexion or extension event (Pearson's R value, -0.085; approximate significance, 0.123).
7. The time at which a maximum or minimum occurred in the flowmetry record was compared with the time recorded for the nearest flexion or extension event.
8. Paired t-test: no statistical difference between the Doppler THM and the palpated CRI.
10. Mean difference between pairs, flowmetry time – palpation time: -0.078 seconds/cycle, S.D., 1.361.
11. Both groups of time values were highly correlated: Correlation, 1.000; significance, 0.000.
12. That is the palpation EXACTLY tracked the 0.1-0.2 Hz frequency oscillation in the flowmetry record.
13. In spite of the 20% frequency modulation in the 0.1-0.2 Hz oscillation

IV. The Second Protocol: The effect of cranial manipulation upon the Traube-Hering-Mayer oscillation. (Ref. 9) If the palpable CRI and low-frequency, 0.10-0.20 Hz, bloodflow velocity oscillations are temporally concomitant, the question arises: Does cranial manipulation exert an effect upon the low-frequency oscillations?
A. Methods
1. Twenty three healthy adult subjects of both sexes participated.
2. They were randomly divided into two groups.
3. Palpation (N=13)
4. OMT (N=10)
5. The laser-Doppler probe was placed upon the left earlobe of each subject.
6. The subject was allowed to lie quietly upon an OMT table for an equilibration period.
7. A baseline blood flow velocity record of five minutes was immediately obtained.
8. Palpation group: The CRI was monitored for five minutes utilizing a biparietal modification of the vault hold.
9. OMT Group: Cranial manipulation, consisting of equilibration of the global cranial motion pattern and the cranio-cervical junction, was applied for a period of 5-10 min.
10. Immediately following this treatment, a 5 min post-treatment laser-Doppler recording was acquired.
11. During the entire procedure, the subject remained on the treatment table, and the laser-Doppler probe was not disturbed.
12. Approximately 30 min of continuous bloodflow velocity recording. (Figure 4)

B. Results
1. For each subject the 4 major component parts of the blood flow velocity record, the Mayer signal, the Traube-Hering signal, the respiratory signal, and the cardiac signal, were analyzed.
2. Pre- and post-contact data were compared for both palpation and OMT groups.

V. The Third Protocol: Cranial Manipulation Induces Sequential Changes in Blood Flow Velocity on Demand. (Ref.10) Since individually determined cranial manipulation changed bloodflow velocity, it was decided to see if an affect could be obtained on demand, using palpation only, alternating with incitant manipulation.

A. Methods
1. Fifteen healthy adult subjects of both sexes participated.
2. The laser-Doppler probe was placed upon the forehead, in the midline, of each subject.
3. The subject was allowed to lie quietly upon an OMT table for an equilibration period.
4. A baseline blood flow velocity record of 5 to 7 minutes was obtained.
5. Following this, 5 to 7 minute periods of incitant cranial manipulation, alternating with cranial palpation only, was carried out for a total of approximately 35 minutes.
6. The timing of the treatment/non-treatment sequence was established prior to manipulative intervention.
B. Results
1. Compressed laser-Doppler-flowmetry, relative blood velocity waveforms, of two subjects treated by cranial manipulation at designated 5 minute (Subject 1) and 7 minute (Subject 2) intervals. (Figure 5)
2. Event marks (EM) indicate points in time when cranial manipulation started and stopped.
3. Expansion of the laser-Doppler flowmetry records of subject 1 showing the THM oscillation. (Figure 6)
4. The top record shows the initial resting segment followed by the first treatment segment; the bottom record shows the analogous segment pair beginning at 18 min
5. Incitant cranial treatment amplifies the power of the oscillation. (Figure 7)
7. Third non-treatment segment
8. Third treatment segment
9. Magnitude difference spectrum: Third non-treatment/treatment segment
   a) 0.1-0.2 Hz frequency oscillation increased.
   b) Heart rate increased from approximately 70 to 82 during cranial manipulation.

VI. The Fourth Protocol: The Effect of an Alternative Medical Procedure (CV-4) upon Low-Frequency Oscillations in Cutaneous Blood flow Velocity. (Ref. 11) Because incitant cranial manipulation affected the amplitude of the low-frequency oscillations it was decided to study the response to compression of the fourth ventricle (CV-4), a manipulative procedure that, during its application, dampens the CRI.

A. Methods
1. Twenty-eight experienced cranial practitioners performed the CV-4.
2. Each with a different subject (N=26; two subjects participated twice).
3. A baseline record of 5 to 7 minutes, the Control (Figure 8) segment was then obtained.
4. During that time no treatment was administered, but the subject’s head rested upon the physician’s hands, in CV-4 position.
5. The Treatment (Figure 8) phase lasted from the time the physician indicated that they had started the CV-4, until they indicated that they had obtained their therapeutic goal.

6. Event marks were entered into the flowmetry record, indicating the start and end of the Treatment segment.

7. The physician removed their hands from contact with the subject's head, and the Response (Figure 8) to treatment was followed for an additional 5 to 7 minutes.

B. Results
2. Mean duration of Treatment 4.43 min.
3. Range 8.65 min (Minimum 1.42, Maximum 10.07).
4. Standard Deviation ± 2.22 min.
5. This is consistent with the reported duration of 3-7 min. (Ref. 12)
6. Observe frequency A, 0.1-0.2 Hz, the low-frequency TH wave.
7. The change between Control, Treatment and Response was significant (P=0.000).
8. Additionally, a spectral peak has been identified at 0.08 Hz (4.8 cpm) that follows the 0.1 frequency peak (P=0.041).

VII. The Fifth Protocol: Recording the Rate of the Cranial Rhythmic Impulse. (Ref.13) It is important to establish normative values when studying physiologic phenomena. We therefore measured the rate of the CRI per minute.

A. Methods
1. The CRI rate was computed from the records of 44 different examiners.
2. Each palpating a different subject.
3. The portion of each record segment selected for this computation was that where the CRI was palpated consistently, without large “palpatory gaps.”

B. Results
1. N  44  
   Range  7.26  
   Minimum  1.25  
   Maximum  8.51  
   Mean  4.54  
   Std. Deviation  2.08  
   Std. Error  0.313  
   Variance  4.32  
2. From these data, the palpated CRI has a rate of 4.54 ± 2.08 (2.5 to 6.5 cpm).

C. Discussion
1. TH oscillation and CRI (palpation of “flexion” and “extension” in a 2:1 ratio. (Figures 9 and 10)
2. The most frequently encountered TH:CRI ratio demonstrated by skilled examiners.
3. But what about the 10-14 cpm originally reported by Woods and Woods?
4. TH oscillation and CRI (palpation of "flexion/extension") in a 1:1 ratio. (Figure 11)
5. This individual will palpate a rate that is twice that of the previous example.

VIII. **The Sixth Protocol:** The palpated cranial rhythmic impulse (CRI): Its normative rate and examiner experience. (Ref. 14) In support of the data presented from protocol 5 a second protocol measuring the rate of the CRI is reported here.

A. Methods
1. N=727 subjects.
2. Participants palpated CRI rates on each other.
3. Half of each group acted as examiners, while the other half were subjects.
4. The examiners palpated the CRI using the classically described vault hold.
5. They were told to count the number of complete biphasic CRI cycles that they palpated during the acquisition period.
6. The number of cycles each examiner reported was kept private so that no one was aware of the rates other participants reported.

B. Results
1. The mean reported CRI rate (N = 727) was 6.88 ± 4.45 cycles per minute.
2. The group was subdivided by experience level and it is of interest to note that examiners with the greatest experience level (N=74) palpated at a rate of 4.78 ± 2.57. As compared to: 4.54 ± 2.08 from Protocol 5.

IX. Conclusions
A. Palpation of the CRI tracks identifiable frequencies in bloodflow velocity. *(Protocol 1)*
B. Cranial palpation alone may be employed as sham treatment in future research into the clinical impact of cranial manipulation. *(Protocol 2)*
C. Cranial manipulation appears to exert effects upon baroreflex physiology. *(Protocols 2, 3 and 4)*
D. Cranial manipulation affects the low-frequency, 0.10-0.20, Hz signal, and to a lesser extent the very-low-frequency, 0.003-0.05 Hz, signal in bloodflow velocity and does so in a manner consistent with the type of manipulative procedure being employed. *(Protocols 2, 3 and 4)*

E. Although not everyone appears to be palpating the CRI at the same frequency, everyone tracks the 0.10-0.20 Hz signal, with the majority tracking at 0.04-0.11 Hz or 1 CRI cycle to 2 low-frequency bloodflow velocity waves. *(Protocol 5)*

F. A new normative range for the palpated CRI of 2-7 cpm (4.5 ± 2.5), as palpated by experienced examiners, has been identified. *(Protocols 5 and 6)*

G. This is consistent with a new frequency (0.08 Hz, 4.8 cpm) identified in bloodflow velocity. *(Protocol 4)*

References: