## In-Time and In-Tune to be

## in Harmony with Mother Earth and Nature.

 Pythagoras, 'Well-Tempered' Tuning and UNFCCC-compliance
www.richardellismedia.com/candc/candc-cube-web-edit.html

http://www.gci.org.uk/animations/vibrating-strings.swf with Contraction $\mathcal{E}$ Convergence [CEC] 'The Well-Tempered Climate Accord' a very widely cited and supported model: http://www.gci.org.uk/endorsements.html

## Pythagoras, 'Well-Tempered' Tuning and C\&C, 'The Well-Tempered Climate Accord'

'All life aspires to the condition of music'. All musicians really do, especially string players, is to 'count' so as to be 'in-tune' and 'in-time'.
In his recent book "The Grand Design", Stephen Hawking cites Pythagoras' discovery of the empirical basis of this counting: -
"According to legend, the first mathematical formulation of what we might today call a law of nature dates back to an Ionian named Pythagoras [who] is said to have discovered the numerical relationship between the length of the strings used in musical instruments and the harmonic combinations of the sounds. In today's language we would describe that relationship by saying that the frequency the number of vibrations per second or 'Herz' value - of a string vibrating under fixed tension is inversely proportional to the length of the string. One could call that simple mathematical formula the first instance of what we now know as theoretical physics."
Here, 'harmonic structure' is discovered as a 'universal law' governing the sub-divisions of a length of vibrating string as a measured and universal 'constant' that is 'in-tune' and 'in-time'. The first two instances of this law give the cadence basis of 'diatonic harmony' and are they are 'perfect': -

Halve-the-string-length/double-the-frequency
This gives the 'perfect' octave [tonic]
'Third-the-length-length/treble-the-frequency'
This gives the 'perfect' fifth [dominant] and so on . . .
In combination, the 'hemiola-structure' - 1:2:3- of this 'overtone' series emerges like this: -


Together these fractions constitute the 'hemiola-structure' where exactly 'Two Groups of Three' and 'Three Groups of Two' occur in precisely the same length of time.

Two Groups of Three Three Groups of Two


This proportionate truth is true when there are hundreds of vibrations per second or Herz [Hz] as pitch and orchestras tune to A 440 Hz . It is also true at one, two and three Hz per second as rhythm or metre.
Think for example of West Side Story: -
"I-like-to, Be-in-a, Me-Ri-Ca", or if you prefer, "Wel-come-to, Pre-si-dent, Gor-Ba-Chev"


However, it is true at any frequency - per second/per decade . . . .


Vibrations per decade
Zoom on the example of Contraction and Convergence [C\&C] rates imaged below for quantitative detail. On the ' $y$ ' axis it is 'in-tune' and on the ' $x$ ' axis 'in-time' i.e. it is not short-term versus long-term, it is full-term and shorter than realized: - http://www.gci.org.uk/Briefings/ICE.pdf


NOTES on 'STRING' \& 'OVERTONE SERIES' from its 'STANDING WAVES' at: -


FUNCTIONAL or 'DIATONIC'HARMONY

FULL STOP

## Pythagoras' 'law' revealed audio-visually

Pythagoras' 'law' is revealed in a string at constant tension and length, in the cello G -String shown for example. The image has Hz values based on $\mathrm{G}=100$ which is equivalent to a Cello G-String. The Hz values have been slowed by a factor of 100 , so the Hz doubling for the octave and trebling for the fifth can be 'seen' and heard The audio-visual file for this is also here: - http://www.gci.org.uk/animations/vibrating-strings.swf
Mouse-touch [one click `on', second click `off'] the gold-coloured buttons in the image to both hear and see how the 'harmonics' of the whole string or the 'overtone series' emerges 'harmoniously' from the 'fundamental' G . The blue buttons for 'chromatic' notes are in between but not 'harmonics'.
C\&C is a function of this structure - internally consistent events per unit time that add up precisely to the stated outcome. Being 'in-tune' and 'intime' with C\&C are a function of this structure at any rates: - http://www. gci.org.uk/animations/C1,C2,C3.swf An A/V concept animation of this is at: http://www.richardellismedia.com/candc/candc-cube-web-edit.html

## UNFCCC-compliance: C\&C as a "Well-Tempered Climate Accord"

The 'perfect fifth cycle' [PFC] in columns 1 and 2, compared with The 'well-tempered fifth cycle' [WTFC] in columns 3 and 4.
Pythagorean tuning preserves the mathematically given fractions for the different 'intervals' within the octave but this makes 'modulating' away from the home key more and more 'out of tune'. Well Tempered tuning makes each of the 12 'semi-tone' steps 'equal in the octave'.
The PFC starts with an 'octave' based on 'G-G1' at 100-200 Hz and plots the Perfect Fifth [PF] 'D' at 150 Hz . It then takes D-D1 based on 150-300 Hz and plots PF 'A' at 225 Hz , and so on . . . The WTFC starts with an octave based on 'G-G1' at 100-200 Hz and plots the Well Tempered Fifth [WTF] 'D' at 149.831 Hz . It then takes D-D1 based on 149.831-299.6614 Hz and plots PF 'A' at 224.492 Hz, and so on . . .

| Hz in Cycle of Perfect Fifths |  | Hz in Cycle of Well Tempered Fifths |  | Pythagorean Comma Hz difference between PF \& WTF |
| :---: | :---: | :---: | :---: | :---: |
| 100.000 | G | 100.000 | G | 0.00 |
| 150.000 | D | 149.831 | D | 0.17 |
| 225.000 | A | 224.492 | A | 0.51 |
| 337.500 | E | 336.359 | E | 1.14 |
| 506.250 | B | 503.968 | B | 2.28 |
| 759.375 | F\# | 755.099 | F\#/Gb | 4.28 |
| 1139.063 | C\# | 1131.371 | Db | 7.69 |
| 1708.594 | G\# | 1695.141 | Ab | 13.45 |
| 2562.891 | D\# | 2539.842 | Eb | 23.05 |
| 3844.336 | A\# | 3805.463 | Bb | 38.87 |
| 5766.504 | E\# | 5701.752 | F | 64.75 |
| 8649.756 | B\# | 8542.975 | C | 106.78 |
| 12974.634 | F\#\# | 12800.000 | G | 174.63 |

AS can be seen in the table, when you complete the 12 note fifth-cycle at the these Hz, the Perfect Fifth Cycle continues through G-G8 [F\#\#], going from 100 to 12974.63 Hz as an 'imperfect fit' with multiples of 100 Hz . Whereas, when you complete this 12 note cycle at the these Hz , the Well Tempered Fifth Cycle completes through G-G8 as you go from G 100 to G8 12800 Hz as a 'perfect fit' within multiples of 100 Hz .
The differences between the values for perfect and well-tempered fifths in the 'fifth cycle' is shown in columns 1 and 3 where the 'values' of the emerging Pythagorean Comma' is shown column 5 of the table.
This is a significant, audible and increasingly obvious difference of pitch [it becomes very 'out-of-tune']. This is why well-tempered tuning was formalized [for example Bach's Well-Tempered Clavier - 48 Preludes and Fugues in all twelve keys both major and minor] in the 18th Century and has been widely adopted as the basis of all music-making since that time.
Pre-tuning keyboard instruments in this 'equal temperament' makes 'modulation' between all keys possible, while remaining 'in-tune' in all keys. In other words, by slightly 'compressing' the perfect fifth so we can have twelve exactly equal semi-tone steps per perfect octave, welltempered tuning makes this twelve-note 'chromatic' division of that octave into a perfect internally consistent whole that is consistently in-tune based at any Hz rates or pitch.
With 'climate politics', emissions-entitlements with C\&C are 'well-tempered' or 'equalized' [per person] rather than 'perfect' and this is the basis for saying that C\&C is a 'well-tempered climate accord'. This argument for `equality of rights per person per unit time' is politically expedient simply to avoid the futile further defence of global inequality. But perhaps more importantly it is technically necessary to preserve internal consistency when calculating all the different rates of C\&C for UNFCCC-compliance and so to keep in-time and in-tune to be 'In Harmony with Mother Earth': - http://www.gci.org.uk/animations/C1,C2,C3.swf

However, whatever rates of C\&C are chosen to respond to the objective of the UNFCCC and actually commit to achieving it, this means simply that the 'unit of measurement' [numeraire] is not 'money'. It means that with C\&C, carbon/per person/per unit time/subject to the objective of the UNFCCC is the primary unit of measurement or the 'numeraire'.
Like this, with C\&C understood as 'The Well Tempered Climate Accord': -

1. the octave [the whole/the unity or the 'full-term contraction-event' needed for UNFCCC-compliance] is preserved
2. the sub-divisions of that event [carbon, per person, per unit-time, subject to the objective of the UNFCCC] are quantized as consistently equal or 'well-tempered' units of that whole over time.
This is true any rates of C\&C rates computed [as here]: -
http://www.gci.org.uk/animations/C1,C2,C3.swf

The 'functionally harmonic' structure of music is an 'attractor' eg:-
The 'Dominant 7th' chord [touch D, A, D, F\#, A, C, D, F\#] 'resolving' to The Tonic chord [touch G, G, D, G, B, D, G, B, D, G] i.e. there is 'pull'.
This same 'Amen Cadence' structure is functional in C\&C. Sub-dividing the whole of the contraction-event, the convergence is 'constitutional' and 'resolves' [pulls together] to meet the UNFCCC-objective. Thus:-

- in the finite period of time left for UNFCCC-compliance [achieving safe and stable concentrations];
- negotiated in a rational, non-random, transparent and proportionate global structure of harmonic feedback or 'cognitive resonance';
- a finite weight of carbon [full-term, global carbon contraction-event];
- is consumed equally and simultaneously by a finite number of people [resolving through convergence to equal per capita rights globally].
It 'knows-where-it-is' because it is rooted in this 'source-code' or fundamental structure. Like an 'Amen Cadence', the functionality of C\&C means it 'knows-where-it-is-going' - to closure from Dominant to Tonic.
In other words, we don't just make-all-this-up-as we-go-along. C\&C knows by how much and by when to go, because we tell it where, by how much and by when, or at what 'rates' to go. Thus, the C\&C framework is 'radar' [where are we?], 'rudder' [where are we going?], 'throttle' [by when do we want to get there?] and 'ration' [against how much of the resource is left, agreeing a 'constitutional principle' of pre-distribution to share this]. All this information is processed in the model from the outset and all rates of C\&C generically show that in authentic integrated climatestrategy, 'guesswork' is subordinate to 'framework' - so the UNFCCC Executive could say about the UNFCCC objective: -
"Stabilization inevitably requires Contraction and Convergence."
UNFCCC: - http://www.gci.org.uk/C\&C_Janos_Pasztor_UNFCCC.pdf
This means that 'UNFCCC-Compliance' is dependent on a C\&C framework. It doesn't mean that a C\&C Framework is dependent on 'UNFCCC-Compliance'. In a phrase, C\&C is input before it is output and this is simply understanding and accepting this sequence ['cap-then-trade'] of cause and effect globally. Deceptively simple, it is the same as seeing that the overtone series is a function of the fundamentals on which it rests and not vice versa: i.e. evolution is a function of constitution - like learning to 'stop-and-play' the violin, you learn 'it', because it doesn't learn you.
C\&C projects a 'Well Tempered Climate Accord' as a 'constitution' for 'Equity and Survival'. C\&C's Pythagorean structure creates a musical framework of proportionality and feedback, within which we can yet globally orient, measure and integrate with resource limits and negotiate how to be 'in-tune' with each other [equity] and crucially 'in-time' together to avoid dangerous rates of global climate change [survival].

Economists however http://www.gci.org.uk/economists.html refer to a Woody Allen one-liner for the 'design-free' answer some need to give to answer the question, 'how long is piece of string?
Ask a string player 'how long is a piece of string?' and the answer will always be 'exactly twice half its length.' However, economists assume questioning 'string-length' is the 'growth issue' and evade it with the 'touch-woody-joke' where, 'eternity is a very long time, especially towards the end'. Then they argue that 'biological diversity' is a function of 'portfolio diversity', where the numeraire is the direction-less dollar [monetary unit] and that, assuming it happens at all, C\&C will be a result of that.
It won't. Just as the economy is a wholly-owned subsidiary of the environment, so the numeraire for UNFCCC-compliance is 'C\&C' or carbon per person, per unit time subject to the objective of the UNFCCC. For economists this means that the numeraire is not primarily the direction-less dollar [monetary unit], it means that if there is a relevant monetary unit, it is a function of C\&C. All this is why GCI's contribution to Working Group Three of the IPCC 2nd Assessment Report in 1994 stated the following: -
"We believe that any proposed solutions to the problems [which both cause and proceed from global climate change] which are not equitable will not work. In a very real and fundamental way, equity is the solution - i.e., properly valuing each other and the planet. A failure to understand and apply this is a failure to appreciate the doublejeopardy in which humanity is now situated. We face the actuality of scarce resources (sink capacity etc) and the increasing potential for conflict with each other over these scarce resources. We do not imagine the solutions that emerge will be based exclusively on the principle of rights to equal carbon usage. However, the analytical tools that we are developing and making available are based on the principle of equal rights to carbon usage, and the results our that our work reveal can be used as a network of reference points. Anyone who wishes to diverge from or ignore the principle can then describe what they propose, and this can be judged against our results. It would then be for the international community, through a reformed and better advised negotiating process, to decide whether or not the degree of divergence proposed was socially and ecologically viable." http://www.gci.org.uk/Documents/Nairob3b_.pdf
UNFCCC-compliance will have to be organised. It will not be a 'design-free-happening' in a 'free-market-accident', following the Woody dictum. If UNFCCC-compliance happens, 'Kyoto's market-based-framework' will transmute to become 'C\&C's framework-based-market'. Quite simply, unless we subordinate this fuzzy monetary numeraire of economics to the fundamental numeraire of UNFCCC-compliance, we will become ever more deeply caught in non-compliance, 'green-wash', alias 'death-wish' and the economics of genocide - especially towards the end.

In his latest book, "The Greatest Show on Earth", the 'evolutionary biologist Richard Dawkins promised this time to simply present the 'evidence' for his Darwinian thesis, rather than engage with the arguments he has said are attacking it. However, in Chapter Two he launches into a vitriolic attack on his 'real enemy'. It transpires that it is not the 'creationists', it is 'the dead hand of Plato'. This dead hand, says Dawkins, is the single thing that over a period of now well over 2,000 years is most responsible for why people do not see the secular reality of 'evolutionism'. This extraordinary statement fails to realize that evolution is a function of constitution.
Three things are relevant here to the rationally cooperative - or 'welltempered' framework - of C\&C: -

1. Plato was a Pythagorean
2. C\&C is Pythagorean
3. Chapter 11 of Dawkins original book "The Selfish Gene", was about 'memes' and it clearly made the point that if it takes cooperation to survive, we'll learn that too.
Dawkins might consider that as things stand, the failure of the 'Kyoto Protocol' to the UNFCCC proves that in the competitive struggle to survive by being the fittest, we are sadly no longer fit to survive climate change and we probably won't. As Tim Smit once sadly observed - the world must get behind C\&C but regarding 'homo sapiens' and climate change he said, "the wise hominid, what a joke."
http://www.candcfoundation.com/pages/indextimsmit.html
So perhaps its worth looking again at what Stephen Hawking recognises as the first instance of what we now know as theoretical physics: -
"In today's language we would describe the number of vibrations per second of a string vibrating under fixed tension is inversely proportional to the length of the string. One could call that simple mathematical formula the first instance of what we now know as theoretical physics."
Is this why Tim Flannery once observed about C\&C: -
"When facing a grave emergency, it's best to be single-minded."
http://www.gci.org.uk/endorsements.html
In Sanskrit this 'single-mindedness' is called 'ekagrata'. It requires us to go beyond ideological banter to teleological purpose.
http://www.gci.org.uk/images/FOCUS_.pdf
As Patanjali says, 'heyam dukham anagatam' or 'pain which has not yet come is avoidable'.

# TUNING TROUBLES 

the Pythagorean Comma<br>[from Harmonograph by Anthony Ashton]

You may have noted that musical intervals do not always agree with one another. A famous example of this is the relationship between the octave and the perfect fifth (3:2).
In the central picture opposite, a note is sounded in the middle at 0 , and moved up by perfect fifths to give the sequence $C, G, D, A, E$, etc. (numbered opposite, each turn of the spiral representing a perfect octave).
After twelve fifths we have gone up seven octaves, but the picture shows that we have overshot the final octave slightly, and gone sharp. This is because (3/2) $12 \sim 129.75$, whereas (2)7=128. The difference is known as the Pythagorean comma, proportionally 1.013643, approximately 74:73.
If you kept on spiralling you would eventually discover, as the Chinese did long ago, that 53 perfect fifths (or Lu) almost exactly equal 31 octaves.
The first five fifths produce the pattern of the black notes on a piano, the Eastern pentatonic scale. The smaller pictures opposite show repeated progressions of the major third (5:4), the minor third (6:5), the fourth ( $4: 3$ ) and the whole tone ( $9: 8$ ) all compared to an invariant octave.
It's strange. With all this harmonious interplay of numbers you would have expected the whole system to be a precisely coherent whole. It isn't. There are echoes here from the scientific view of a world formed by broken symmetry, subject to quantum uncertainty and (so far) defying a precise comprehensive 'theory of everything'.
Is this why the 'near miss' is so often more beautiful than perfection?


