Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

Chronobiology of Trees and the Fourth Phase of Water

Ernst Zürcher

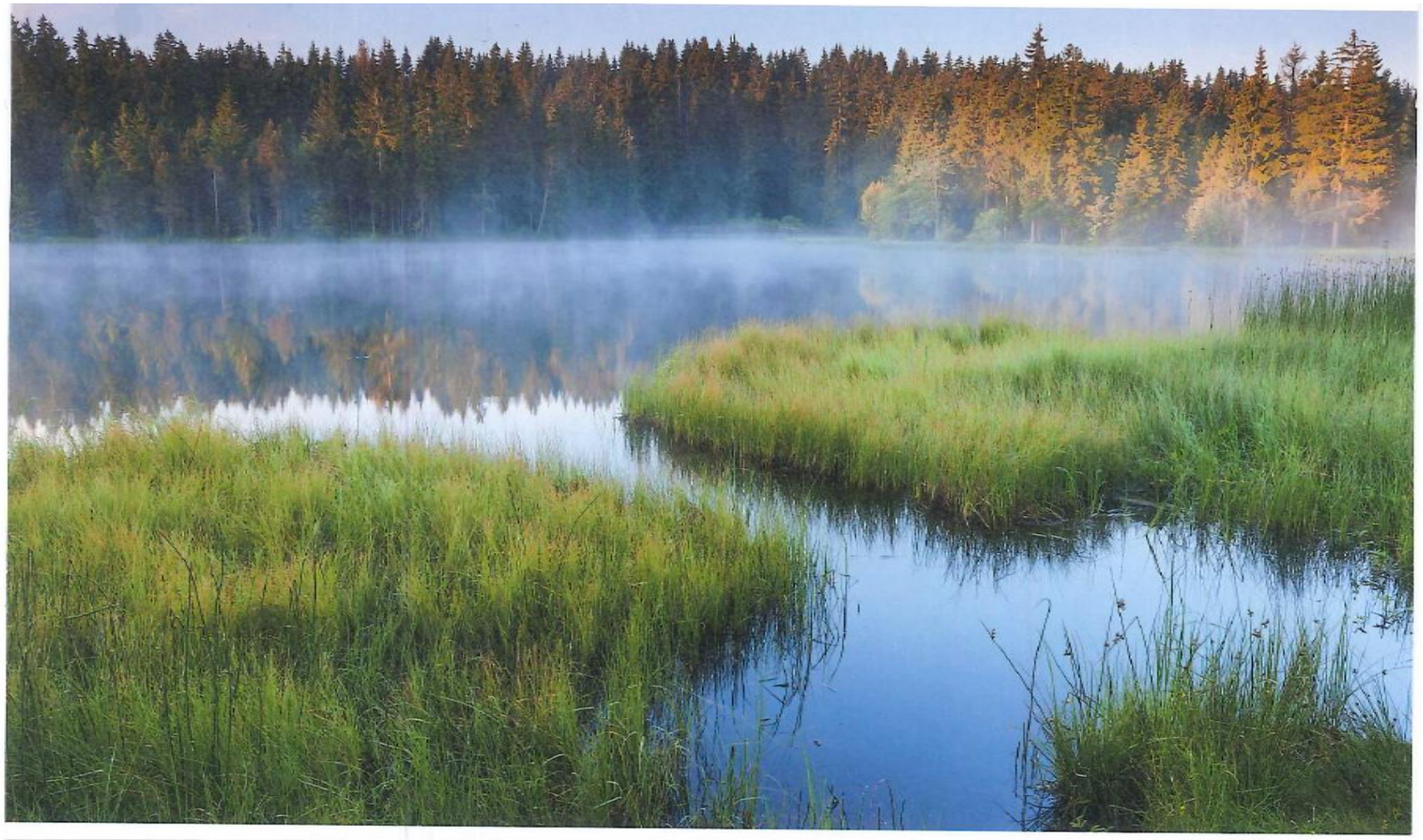
**Bern University of Applied Sciences /
Architecture, Wood and Civil Engineering**

- Conference on the Physics, Chemistry and Biology of Water, Pamporovo, Bulgaria , 9 – 12.Oct. 2014

Trees:

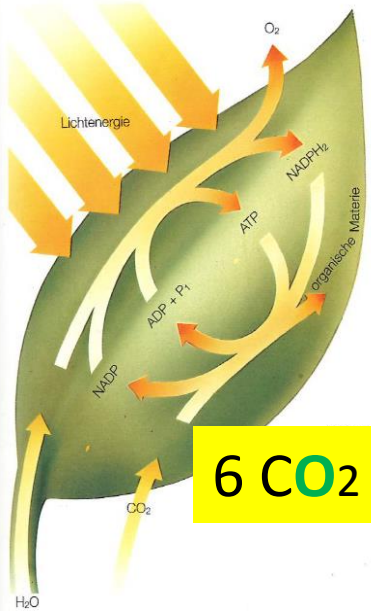
Giants of
Space and Time

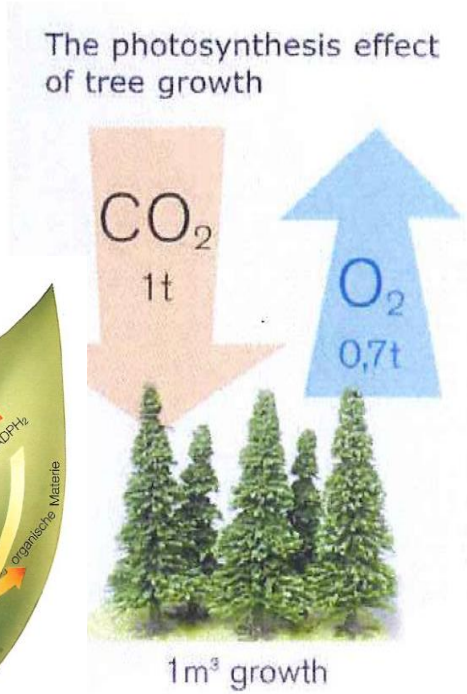
Forest and Trees: interfaces of exchanges

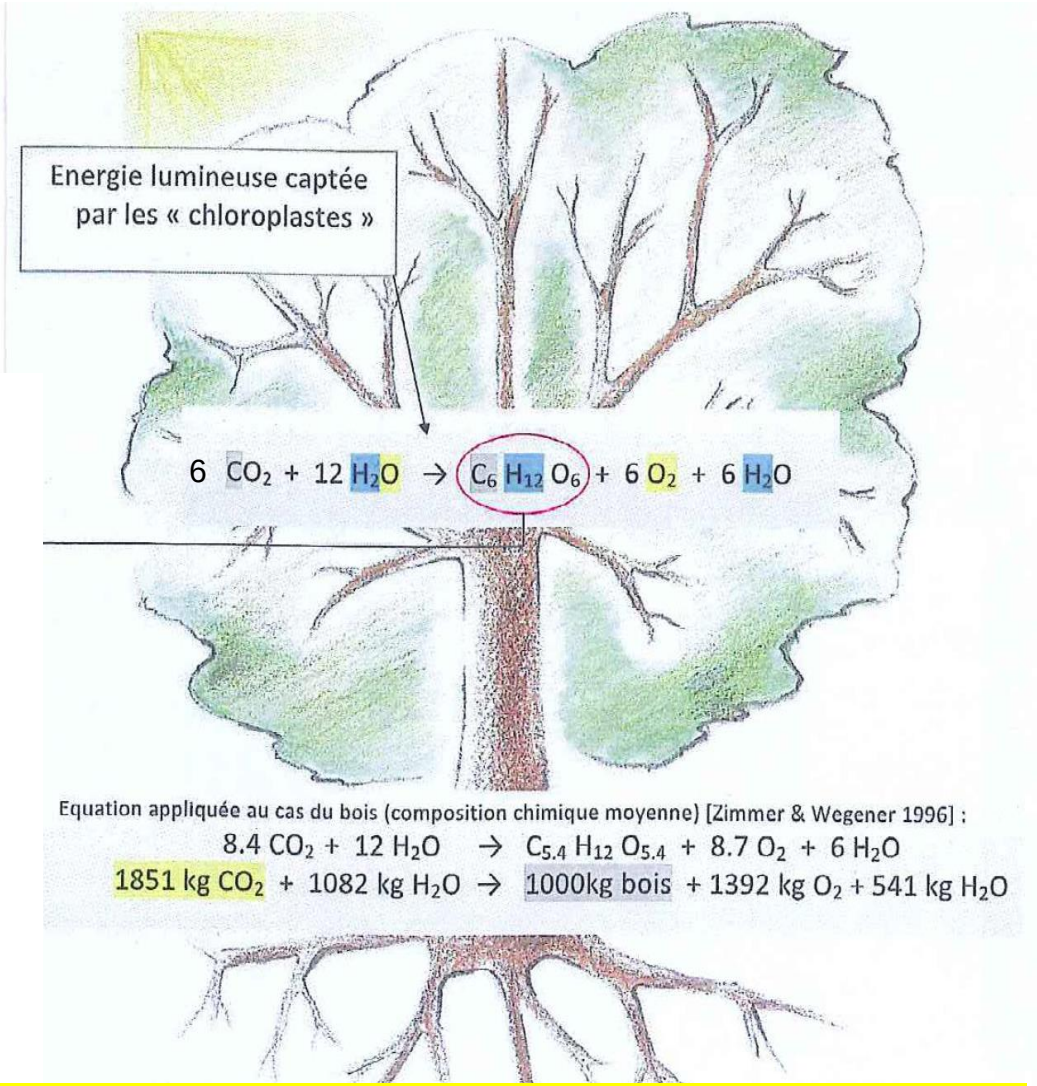


Components and products of photosynthesis :

new water usually ignored



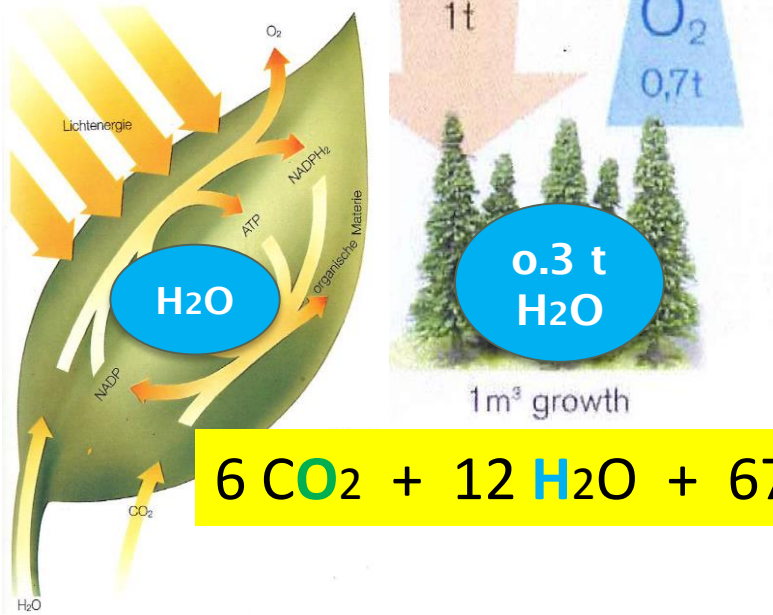


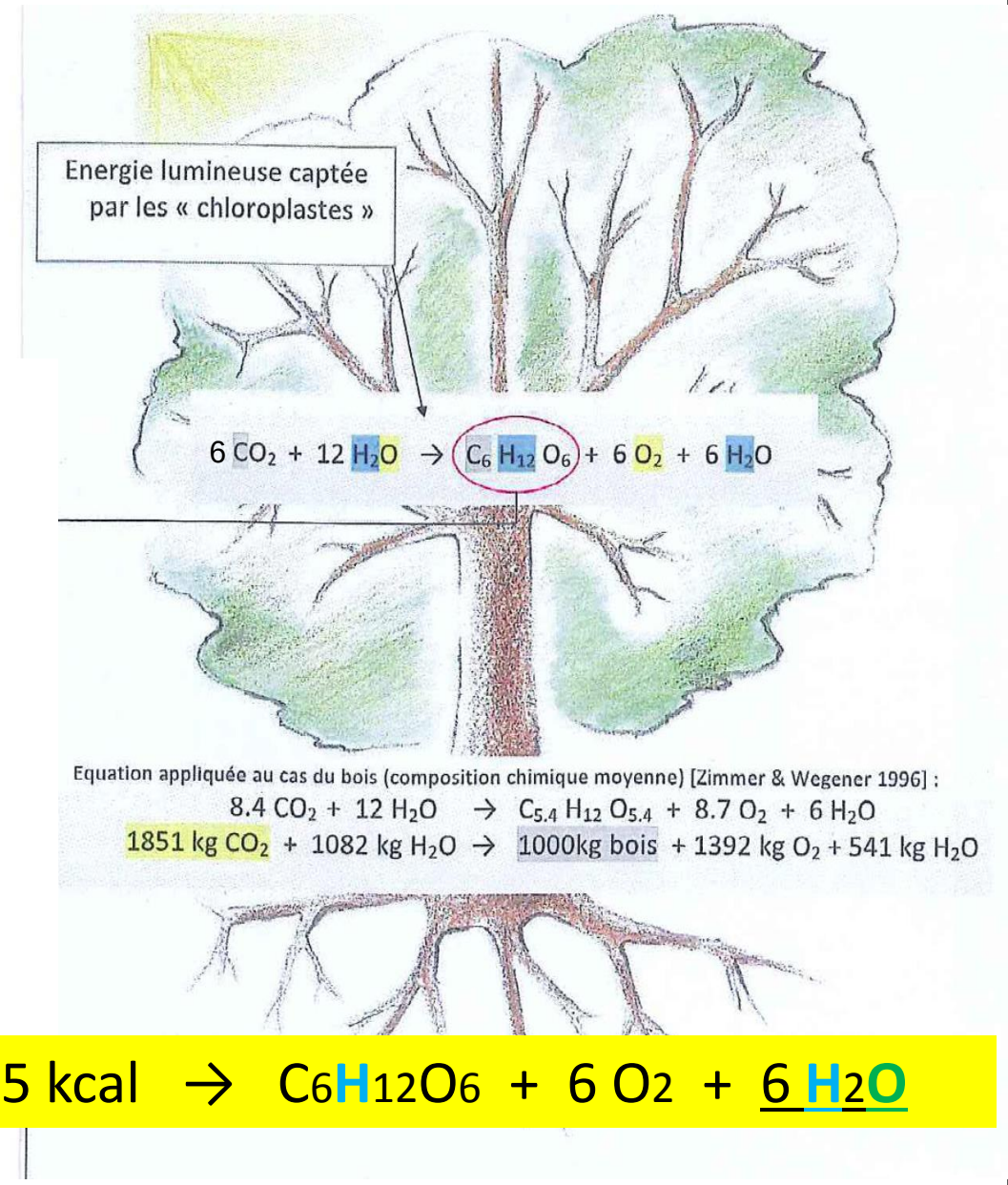


$$6\,CO_2 + 12\,H_2O + 675\ kcal \rightarrow C_6H_{12}O_6 + 6\,O_2 + 6\,H_2O$$

Components and products of photosynthesis :

new water in important amounts

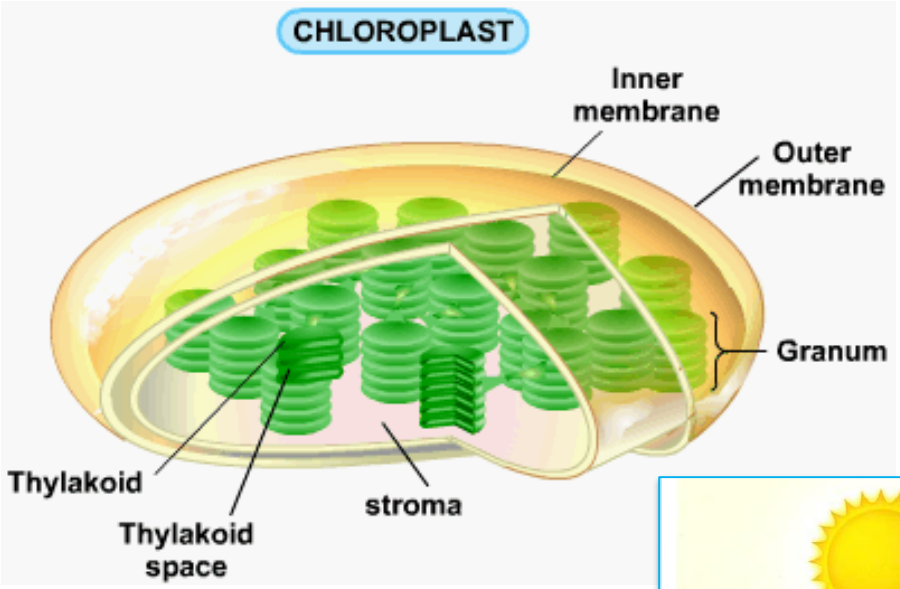


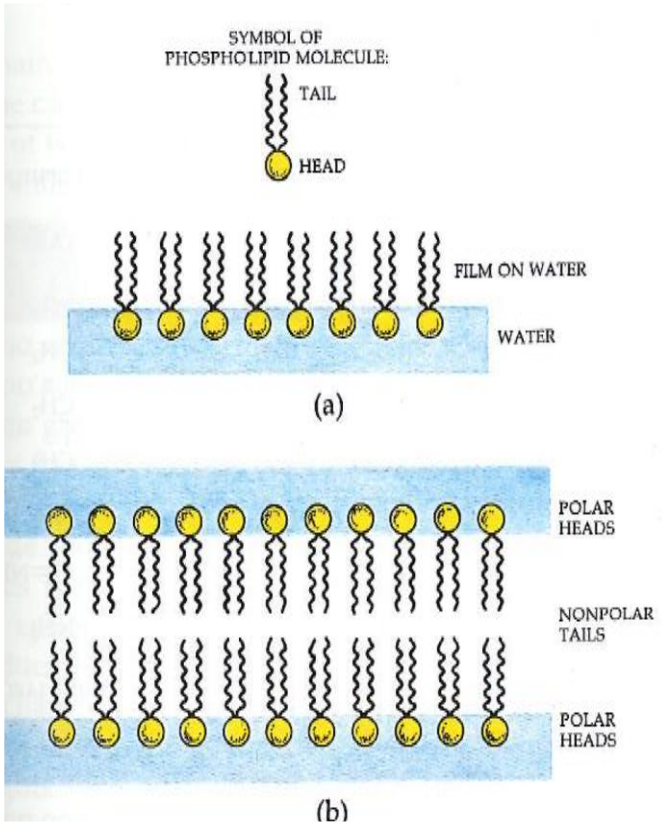


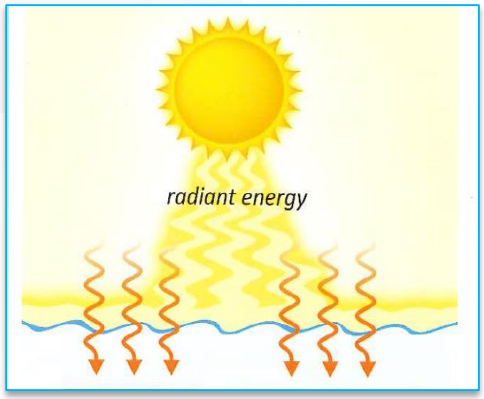
$6\ CO_2 + 12\ H_2O + 675\ kcal \rightarrow C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$

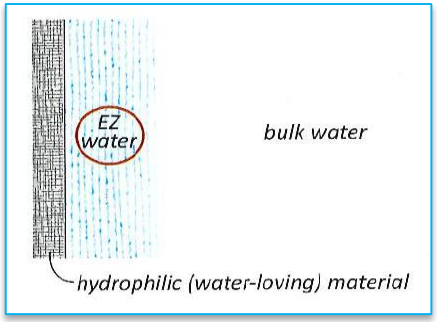
Photosynthesis :

occuring in a hydrophilic membrane system



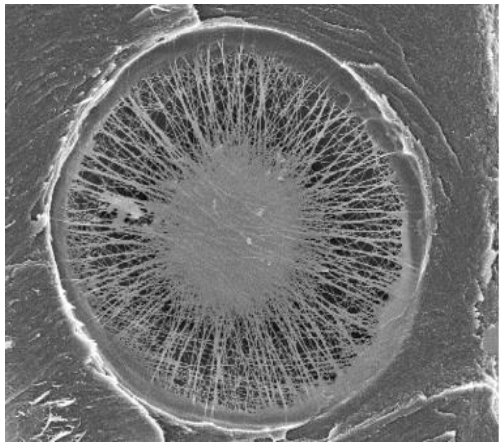


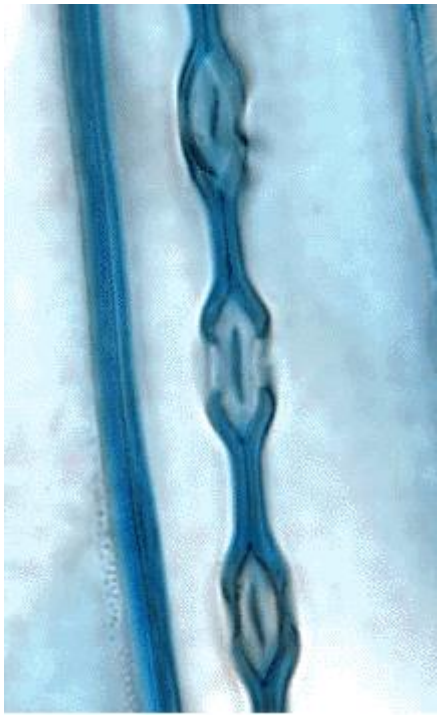


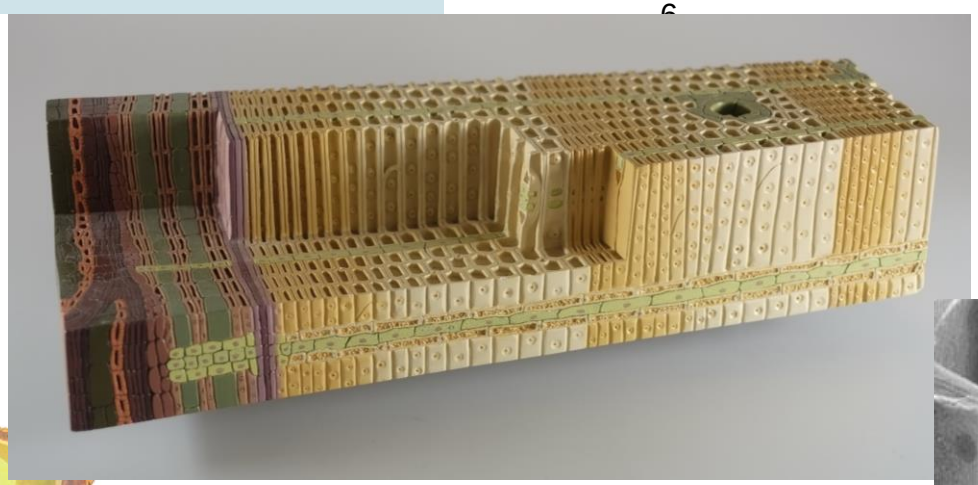


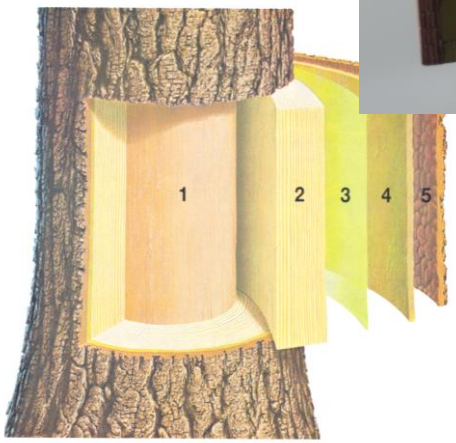
The flow of water to the crown :

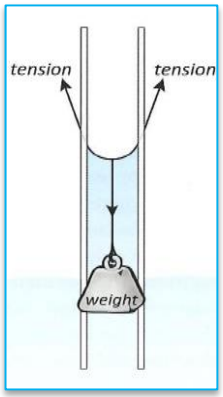
under negative pressure (pull), passing bordered pits from tracheid to tracheid (- softwoods -)

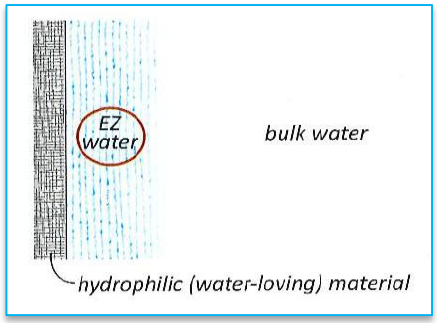


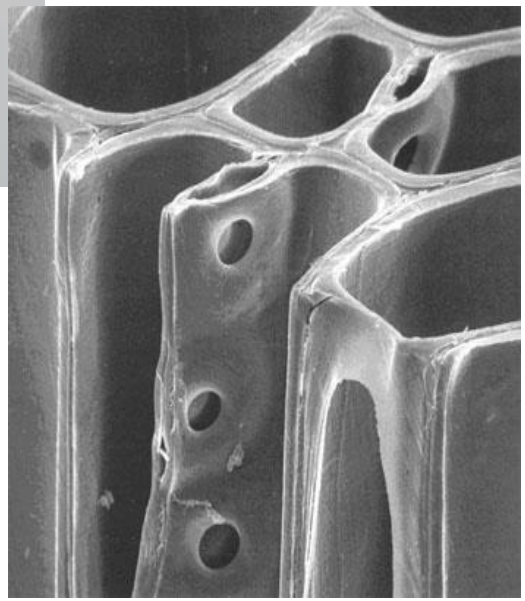






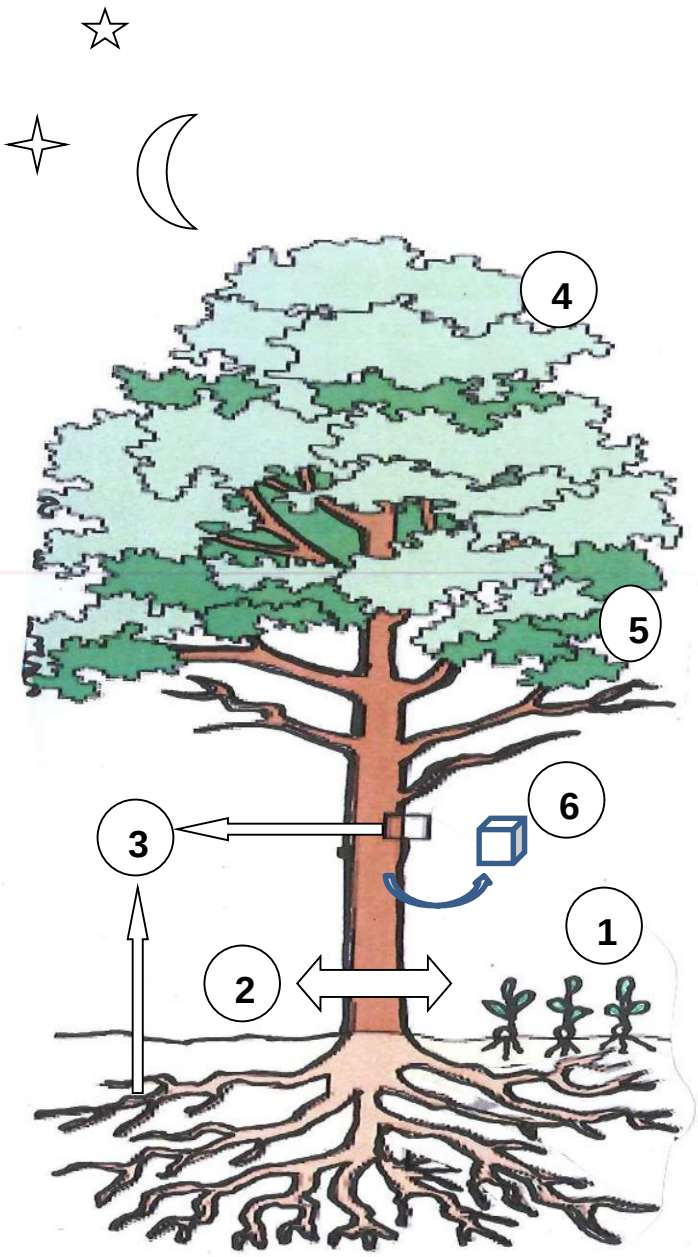




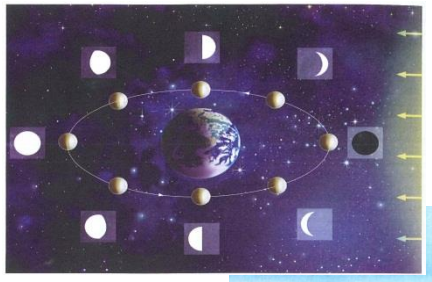


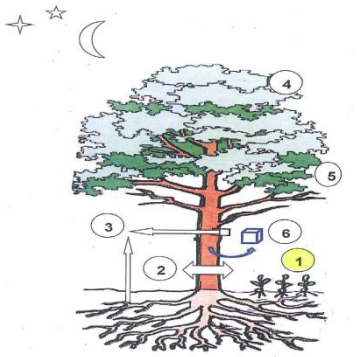
6 Research fields in chronobioogy of trees

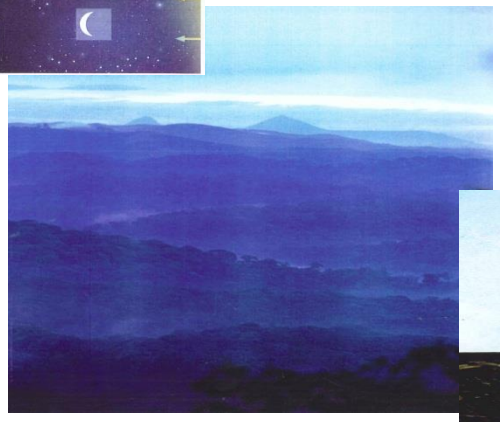
1. Germination and initial growth
2. Stem diameter fluctuations
3. Bio-electric potential variations
4. Pulsation of buds
5. (The Golden Section in Space and Time)
6. Tree felling date and wood properties



Germination and initial growth: lunar-synodic fluctuations

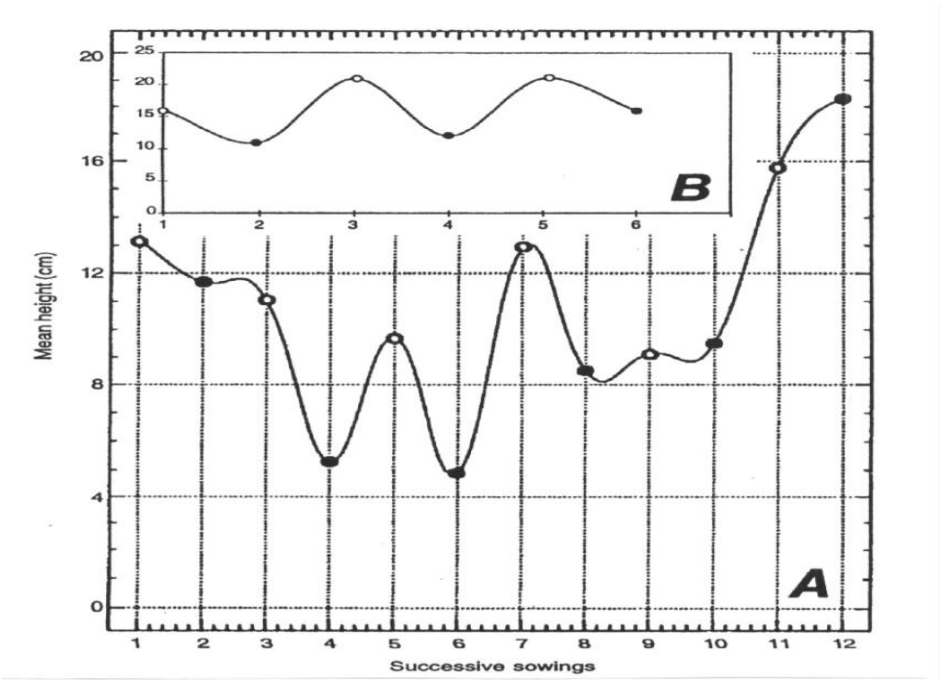




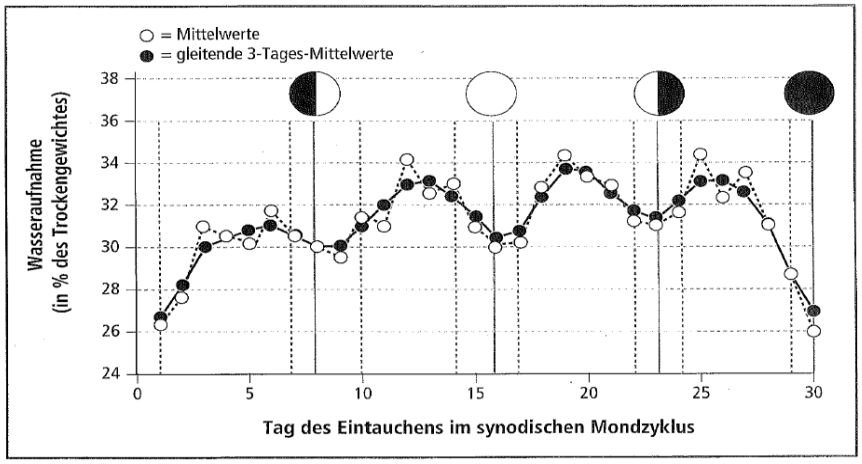


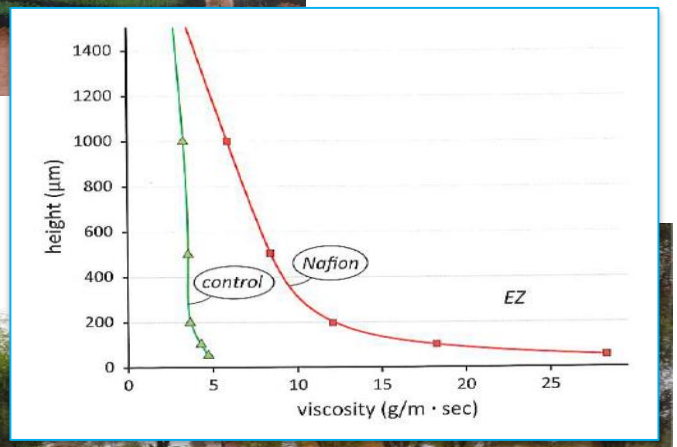
A tree nursery situated in the tropics, in Rwanda, offered interesting conditions for experiments on the germination and initial growth of woody species according to the moon influence, since temperatures and day-lengths were less variable than in higher latitudes. In addition, the dry seasons could be compensated by watering. The work occurred over 3 years: preliminary trial, main trial with 12 sowings of 4 repetitions of 50 seeds, then control and complementary trial. The sowings of the main trial were carried out 2 days before the full moon, alternating with sowings 2 days before the new moon, as suggested by Kolisko's work.

For African musizi (*Maesopsis eminii,* Rhamnaceae), a species found from Liberia to Kenya, the speed and rate of germination, as well as the mean and maximum values of growth in the first months, vary in a clearly rhythmic manner, with higher values for sowings just before the full moon (A: Zürcher 1992). Similar trials with dryland species confirmed the phenomenon (B: Bagnoud 1995).



Synodic moon rhythms in water absorption by seeds: periodicity of lunar weeks (7.4 d)

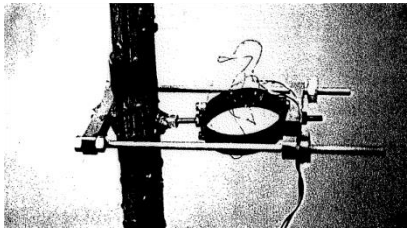


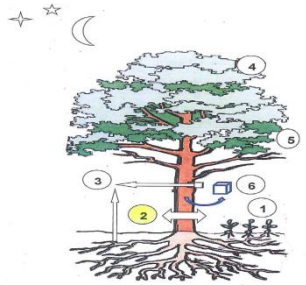


Stem diameter fluctuations in phase with tides

When a pluridisciplinary team took up the results of work already published by Cantiani et al. (1994) on the variations in diameter of trees kept in constant conditions, they demonstrated the existence of a synodic lunar rhythm at a daily level, corresponding to gravimetric tides. Behind the photo-thermoperiodic cycle of 24 hours known for most physiological processes and corresponding to the influence of the sun, An international research team (Zürcher, Cantiani, Sorbetti-Guerri, Michel 1998) found that the diameter of tree-trunks also changes according to a lunar cycle with a period of 24.8 hours. This raises the question about the processes leading to these fluctuations in diameter, and suggests that it could be an alternation in the relative water content of the cell wall compared to the cytoplasm.

Just recently, a new overhaul of Cantiani's 1994 data already analysed by Zürcher et al in 1998, and an in-depth analysis of other data of the Florence researchers about trees living in open conditions, enabled a spectacular confirmation of the role of gravimetric tides in tree physiology. These same authors also put forward the hypothesis of a possible role of geomagnetic field activity (Barlow, Mikulecky and Strestik (2010).





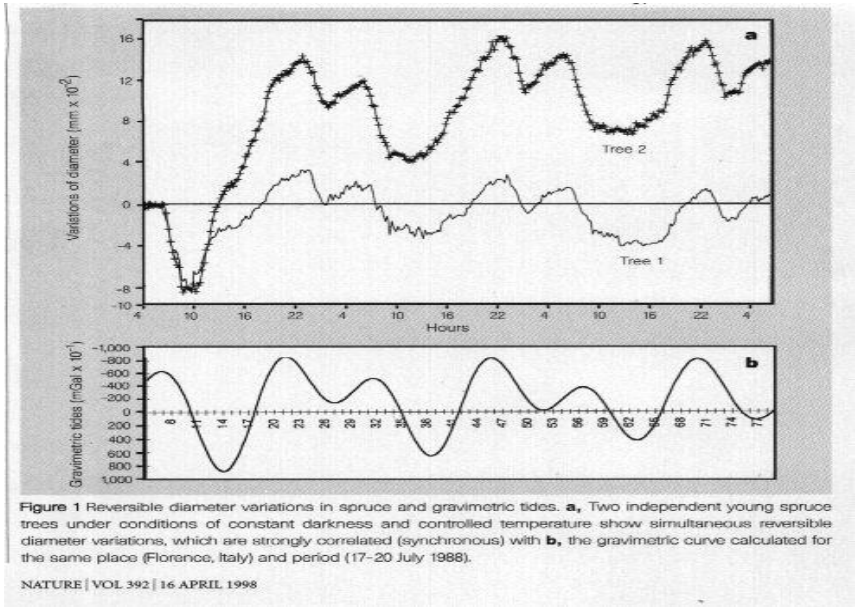


Figure 1 Reversible diameter variations in spruce and gravimetric tides. **a,** Two independent young spruce trees under conditions of constant darkness and controlled temperature show simultaneous reversible diameter variations, which are strongly correlated (synchronous) with **b,** the gravimetric curve calculated for the same place (Florence, Italy) and period (17–20 July 1988).

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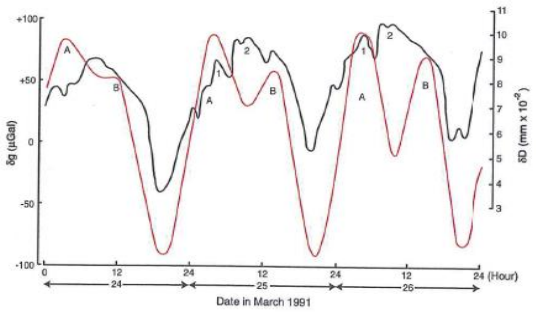
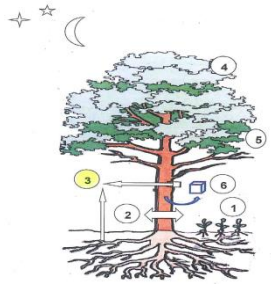


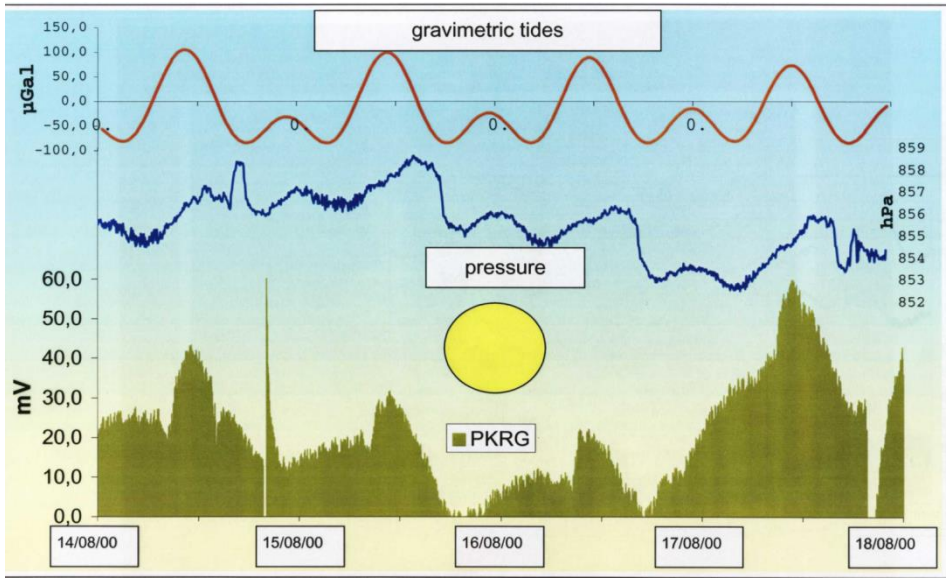
Fig. 9 Time series of δD (*black line*) recorded from a stem of *Juglans regia* during March 1951 and the contemporaneous variations of δg (*red line*)

Bio-electric potential variations in phase with tides

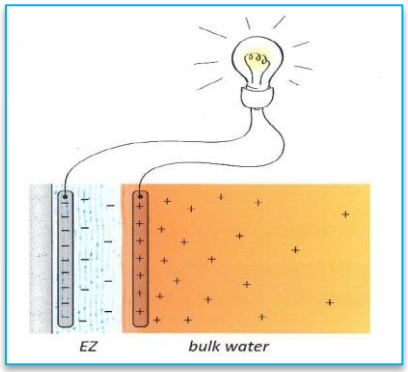


This last lunar phenomenon (tides in trees) has recently been elegantly confirmed and had new light thrown on it, following on from Burr's work from 1944 to 1972. Holzknecht (2003) presents an extremely sensitive device to measure bio-electric potentials of standing trees, applied to spruce (*Picea abies*) and Swiss stone pine (*Pinus cembra)*. It enables the detection of rhythms in phase with gravimetric daily tides and with the synodic lunar monthly cycle, during the trees' rest period in the winter. On the other hand, the ordinary 24 hour period predominates while the trees are growing.

Another interesting phenomenon visible on the shown graph, is that during calm weather periods, the atmospheric pressure (blue curve) also fluctuates in phase with the gravimetric tides (red curve).



To this topic: see Electrophysiology of Plants (Volkov 2012)



Pulsation of buds and planetary alignments

Lunar rhythms in the shape of organs, analogous to those of the trunk diameters described above, had already been discovered by Edwards (1982), thanks to a meticulous series of photographic observations of tree buds. With the help of a shape factor developed in projective geometry, each bud, whether it be spherical, elliptical or ovoid, can be characterized by a unique parameter Lambda. This shape, therefore lambda, not only changes radically at budbreak, but varies subtly around the characteristic value through the bud's existence, from formation to budbreak.

The phenomenon consists of a rhythmical elongation and relaxation of the buds through the winter, as though there was breathing or a subtle heartbeat, already hinting at tiny movements of opening and closing. Edwards also indicates that this fluctuation in shape is synchronised for some species with the position of the moon relative to the sun (synodic rhythm) but for others with the alignment of the moon with certain planets (e.g. Saturn for beech *Fagus sylvatica*, Mars for oak *Quercus sp*.).

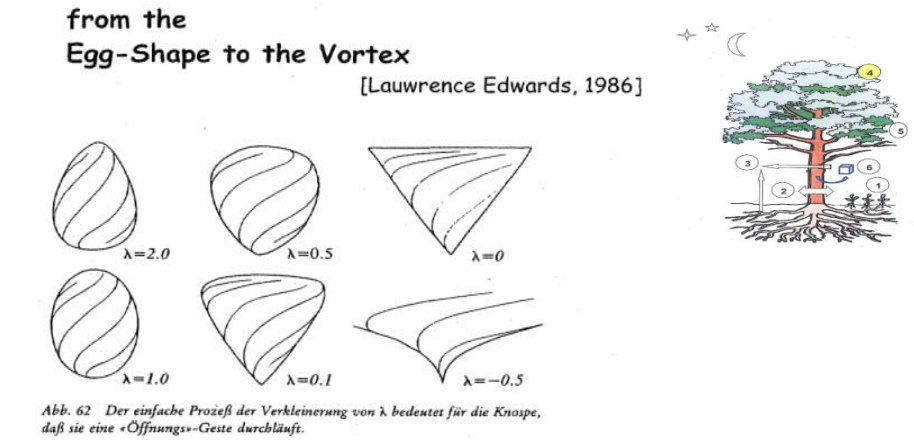


Abb. 62 Der einfache Prozeß der Verkleinerung von λ bedeutet für die Knospe, daß sie eine «Öffnungs»-Geste durchläuft.

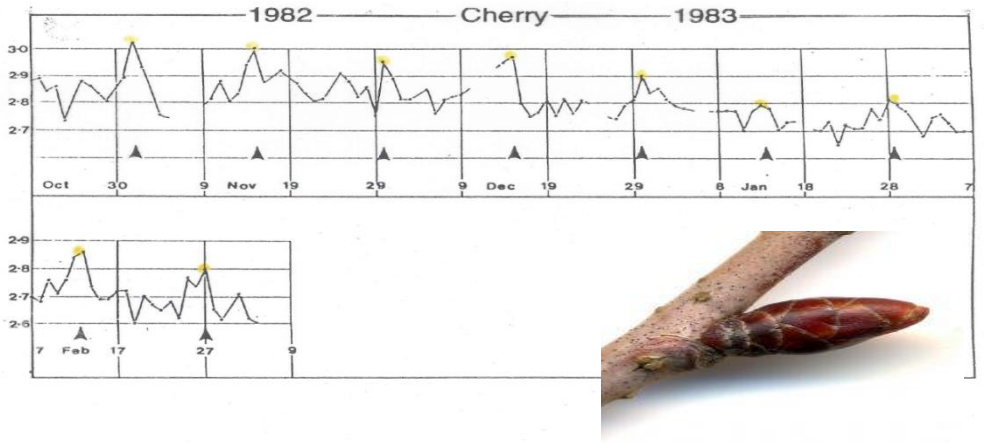
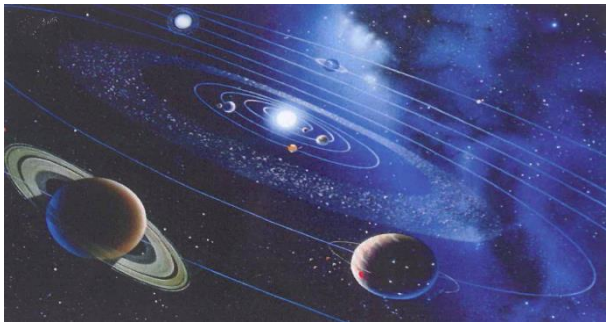


Figure 115. Mean λ values for Cherry leaf buds, winter 1982–83, with corresponding alignments of Sun and Moon. [L. Edwards 1993]

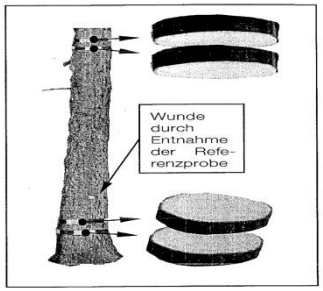


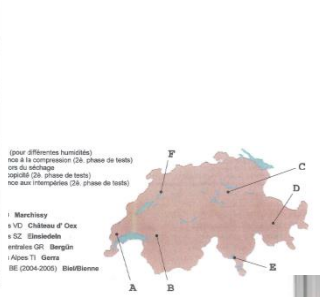
Tree felling date and wood properties

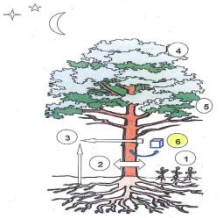
In forestry traditions, criteria about choosing felling dates according to the season and lunar cycles still exist all over the world. Samples to test and analyze must come both from the partly living sapwood and from the heartwood usually much dryer and devoid of active cells: this part constitutes most of the volume of the stem for adult trees. The phenomena and processes involved are therefore mostly physical, and only partly biological .

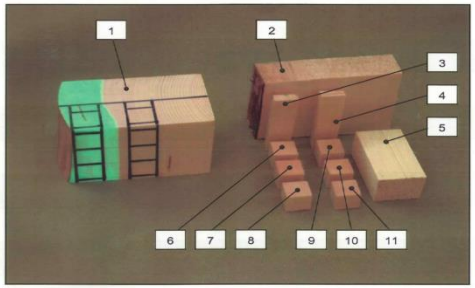
In order to deal with the question more fundamentally and with a large data base, a new trial was conducted simultaneously in 4 sites in Switzerland, with 48 successive fellings (each Monday and Thursday) –- with no link to an experimental hypothesis -– of 3 trees per site over 5.5 months, representing a total of 624 trees felled over the winter 2003 to 2004. The species used were spruce and sweet chestnut. Each tree provided a series of samples of the sapwood and of the heartwood, from different parts of the stem. The behavior of this material during drying under standard conditions was monitored. Among the different rhythms observed and statistically confirmed for 3 principle criteria was water loss, which for spruce varied systematically between the fellings just before the full moon and those just after. This type of variation is probably due not to differences in initial water content, but to the fact that the forces binding water to the cell walls of the ligneous tissue could be subject to fluctuations. The ratio between water easily extractible from the wood, called “free”, and that extracted below the saturation point of the fibers, or “bound water”, fluctuates according to the lunar cycles, and probably also according to the seasons. It should be noted that the characteristics of the rhythms are species-specific.

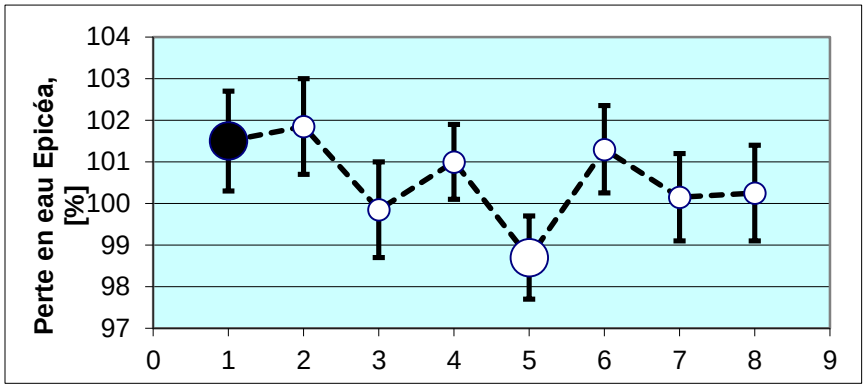
The statistical analysis indicates unexpectedly not only different synodic rhythms, but also a marked sidereal rhythm (Zèrcher, Schlaepfer, Conedera, Giudici 2010).

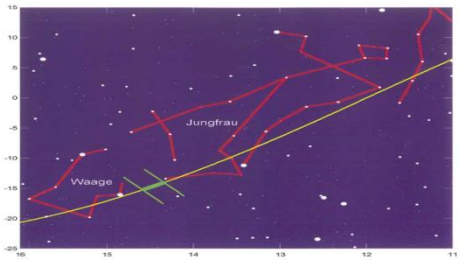


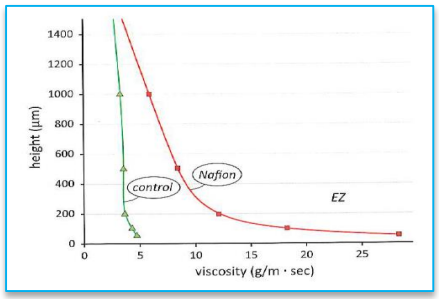












Chronobiology of Trees and the Fourth Phase of Water → Time as a variation factor:

- → Amount
- → Viscosity
- → Density / Volume
- → Energy absorption / Electrical load
- → Significance for plant and human health

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