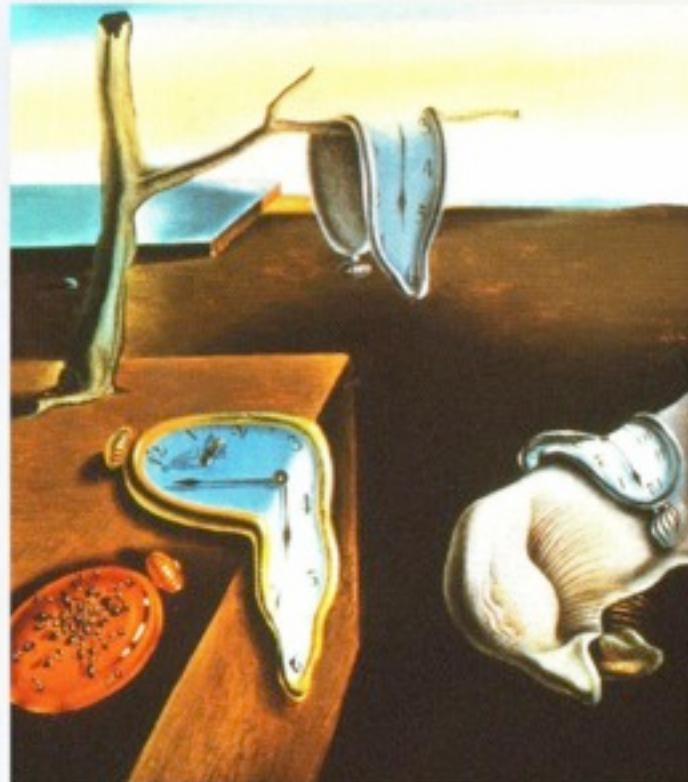


FIFTEEN CENTS

JULY 2, 1911

# TIME

*How and why we do measure the time?*



Kerecson

Volume XVII

Lluís Galbany

Thursday 3rd May - 15.00h IFAE Seminar room

Number 3

# Outline

- Time
- Calendars
  - Periods
  - Types
- Watches
- GPS
- Summary & Conclusions



# What is time?

Antiphon the Sophist: “*Time is not a **reality**, but a concept or a measure*” S.V BC

Newton: “*Absolute, **true**, and mathematical time , in and of itself and of its own nature, without reference to anything external, **flows** uniformly and by another name is called duration. Relative, apparent, and common time is any sensible and external measure of duration by means of motion; such a measure—for example, an hour, a day, a month, a year—is commonly used instead of true time.*” – *Principia* SXVII AC

Leibniz: “*A fundamental part of an **abstract** conceptual framework, together with space and number, within which we sequence events, quantify their duration, and compare the motions of objects.*”

Kant: “*A priori **intuition** that allows us to comprehend sense experience.*”

Einstein: “*that which a clock measures*” -> 4D

USEFULNESS -> to put in order events



“I think the answer is time “ Closer (movie)

# Cycles

DAY/NIGHT

SUN HEIGHT

MOON PHASES

TEMPERATURE

RIVERS GROWTH – DRY EPOCHS

FLOWERING – LEAF FALL



# Astronomic cycles

## DAYS:

Sidereal day: Between fixed point culminations. 23h 56m 4,09s

Sidereal time:  $\theta$  of Aries point

True solar day: between sun culminations

True solar time:  $\theta$  of sun

Average solar day (asd): between average sun culminations. 24h

Average solar time:  $\theta$  of average sun

Lunar day: between Moon culminations. 24 h 50 min.

(Earth rot. + Moon trans.) (tides slow down 25m each 12h)

## YEARS:

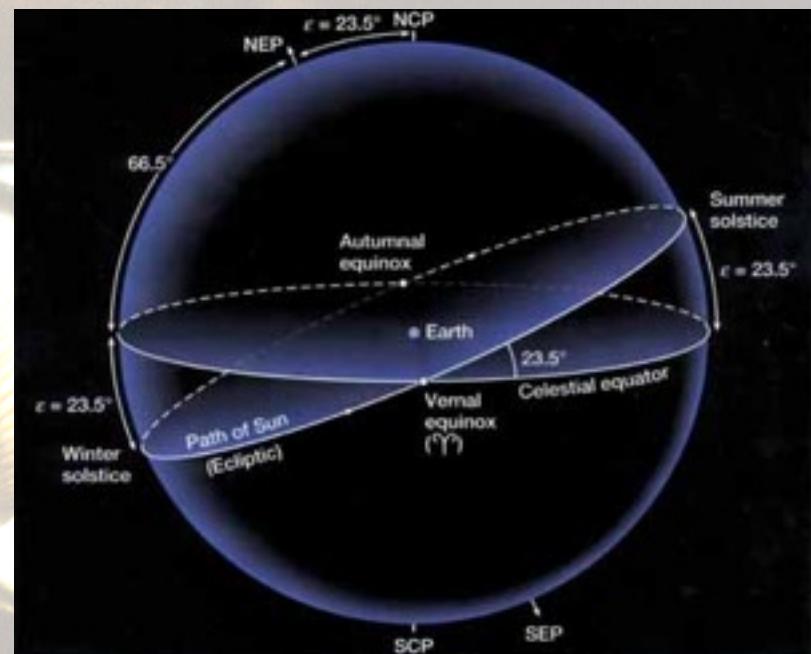
Tropic year: 365,2422 asd (Aries)

Sidereal year: 365,2564 asd (Fixed point) (eq. precession)

Lunar year: 354,36 asd (12 sinodic months)

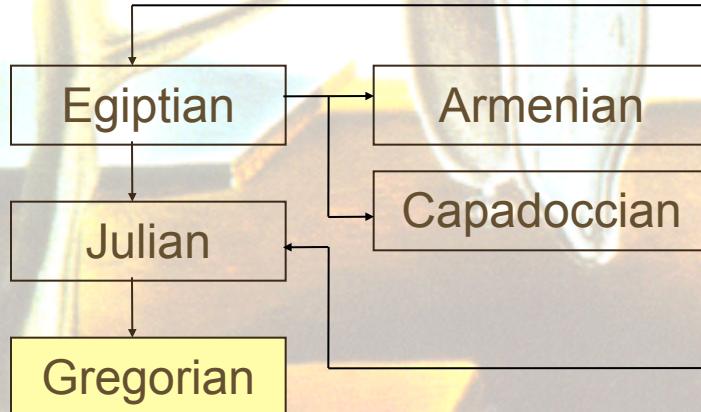
## MONTHS:

Lluís Galbany - IFAE thursday meeting 3rd May  
Sidereal month: 27,32 asd (true orbital period of the moon)

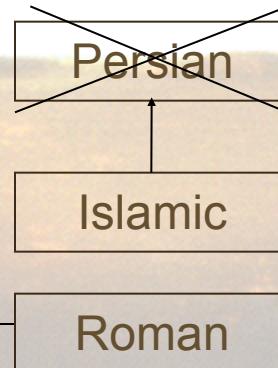


# Calendars

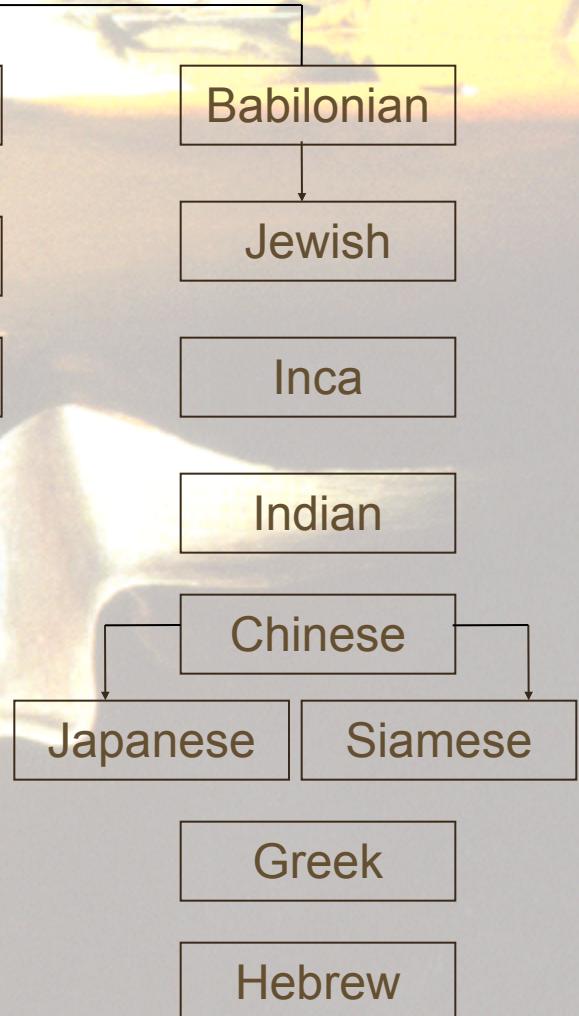
## SOLAR



## LUNAR



## LUNISOLAR

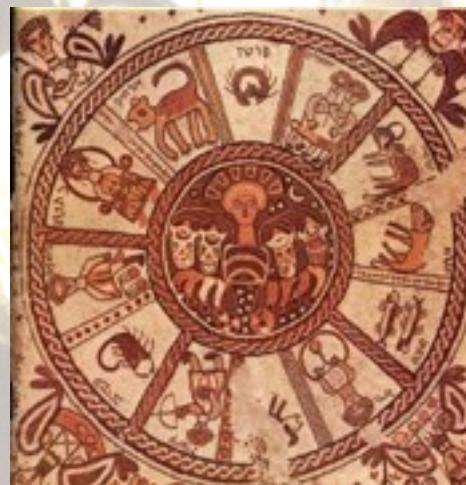


# Babylonian calendar

- Different empires with different calendars. Chaldean imposed theirs
- Year begins in Spring
- 12 ARAJ (months) of 28, 29 or 30d begin with new moon = years between 354 and 360d
- To synchronize months with seasons they added the EMBOLISMAL month when necessary
- Finally rounded to 12m of 30d = 360d = 1y
- Days begin with sunrise. After mesopotamic invasion, days begin with sunset
- 1d = 2 BERU of 12h

Months:

nisanu, airu, sivanu, duzn, abu, elulu, tashritu  
arajshamna, kisiliyu, zebitu, sabatu y adaru



Cicles:

1 Sosos = 60y  
1 Neros = 10 sosos  
1 Saros = 6 neros  
1 Era = 120 saros

# Egyptian calendar

1st solar calendar of the history (4236 BC)

- Every 365d the cycles of Nile's flood repeat. New year at the summer solstice (when Sirius rises parallel to sun)
- $1y = 365d = 12m \text{ of } 3w \text{ of } 10d + 5d \text{ epagomens (osiris, horus, seth, isis, neftis)}$
- 3 seasons of 120 days (AJET flood, PERET sow & SHEMU harvest)
- Every 1460y delay 1y (Sothiac cicle of Sirius)
- Canopus reform (238BC)  
 $1y = 365,25d$  (every 4y add 1d)



Weeks of 7 days (1 for each planet) ??

Months:

tot, chocha, famenoz, payni, paofi, tybi, farmonti, epifi, atir, mechir, pachon y mesori.

# Roman calendar

Began on the 21st of April 753BC  
(ab urbe condita = Rome foundation)

- Year begins on March 1st
- 1 year = 10 months (4 of 31d & 6 of 30d) = 304d
- So short. 700BC Pompilus adds 2 months (at the beginning Februarius 28d and at the end Januarius 29d) and changes the duration of the months to make a year of 355d (~lunar year)
- Every 2 years adds 1 month (mercedonius 22 or 23d) -> 1y = 366,25d

Tenedos reform (450 BC)

- Every 8 years adds 3 times mercedonius (octoeterida)  
1y = 364,2d

Martius 31	Sextilis 30
Aprilis 30	September 30
Maius 31	October 31
Junius 30	November 30
Quintilis 31	December 30

Marte, Apolo, Jupiter, Juno & order...



# *Julian calendar*

- Juluis Cesar apply the Canopus reform to the roman calendar 46BC
  - Year begin Januarius 1st
  - 12 months of 30 and 31d
- 45BC confusion year: 445 days (2 months of 33 & 34 days after november)
- 1 year = 365 days
- Every 4 years there was two Februarius 23rd (bi-sexto calendas)
- 44BC Julius murdered. The Pontifices change the leap year every 3y (Julius)
- 23BC changes the name August of 31d
- 8AD August put the leap year every 4 again
- 321AD Constantin imported the 7d week from the Jewish calendar. Sundays free days and set the festive days.
- 527AD Dionisium set Jesus birth 753y after Rome foundation.  
607AD Bonifacium IV changed from ~~every 4 years~~ to every 128y !!!!

# *Gregorian calendar*

- Arise from the problem to set the Easter Sunday (resurrection day)
  - Nicea's council(325AD ->Catolicism): the first Sunday after the first new moon after the spring equinox
- Gregorium XIII wanted to correct this error fitting the calendar to the tropic year (365,2422 asd).
- Leap years the divisibles by 4 except those are finished by 00 and are not divisibles by 400.
- Gregorian year > julian year (26s)  
Error 1 day every 3323 years
- Founded October 4th 1582AD and the next was October 15th, due to the accumulated error

# *Maya calendar*

- 2 calendars:
  - TZOLKIN (holy) 260 d: Based in the Pleyades cicle. 4 seasons of 65d. 13 UINAL (months) of 20 KIN (days)
  - HAAB (civilian) 365d: solar. 18 months de 20 days + 5 UAYEB ERA (Long count) 1872000d
- Cyclic: The 5th maya era began August 13th 3114aC and will finish December 21st 2012
- Calendar round (52 Haabs = 73 Tzolk'in)
- 18 Uinal = 1 Tun
- 20 Tun = 1 Katun
- 20 Katun = 1 Baktun
- 13 Baktun = 1 Era

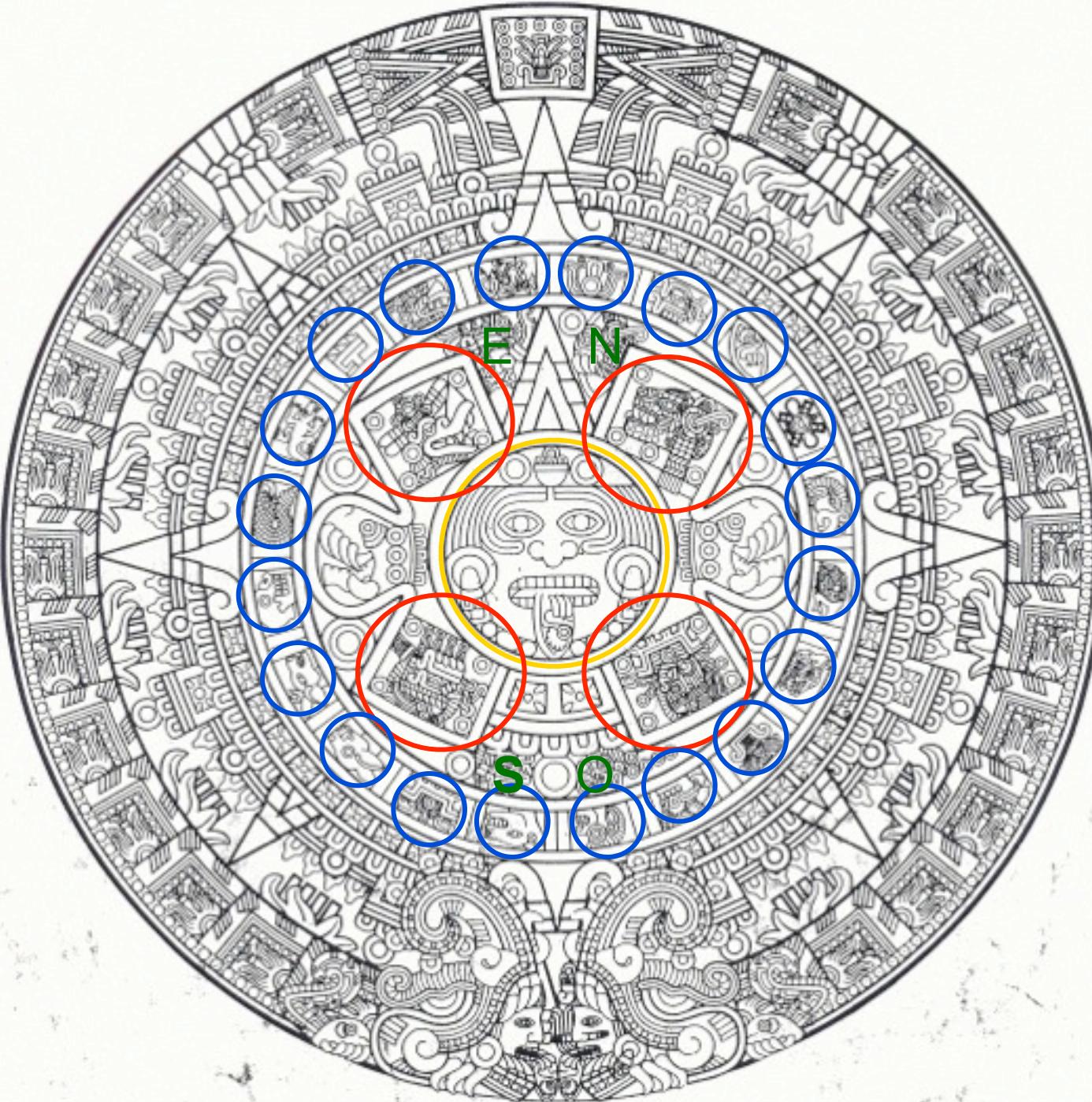
*Tzolk'in, the oldest calendar??*

*Cicle Venus (584d) -> guerres*

# *Aztec calendar*

- Similar but with aztecs nouns
  - TONALPOHUALLI (holy) 260d: 20 weeks of 13 days
  - XIHULTI (civilian) 365d: 18 months of 20 days + 5 NEMONTEMI (emptys). 5d each week and 4 weeks each month. Leap years. Began on February.
- 1 Fuego Nuevo = 52 xihulti = 73 tonalpohualli
- 20 Fuegos Nuevos = 1 Sol





1st era

Giants attacked by jaguars.  
(dinosaures)

2nd era

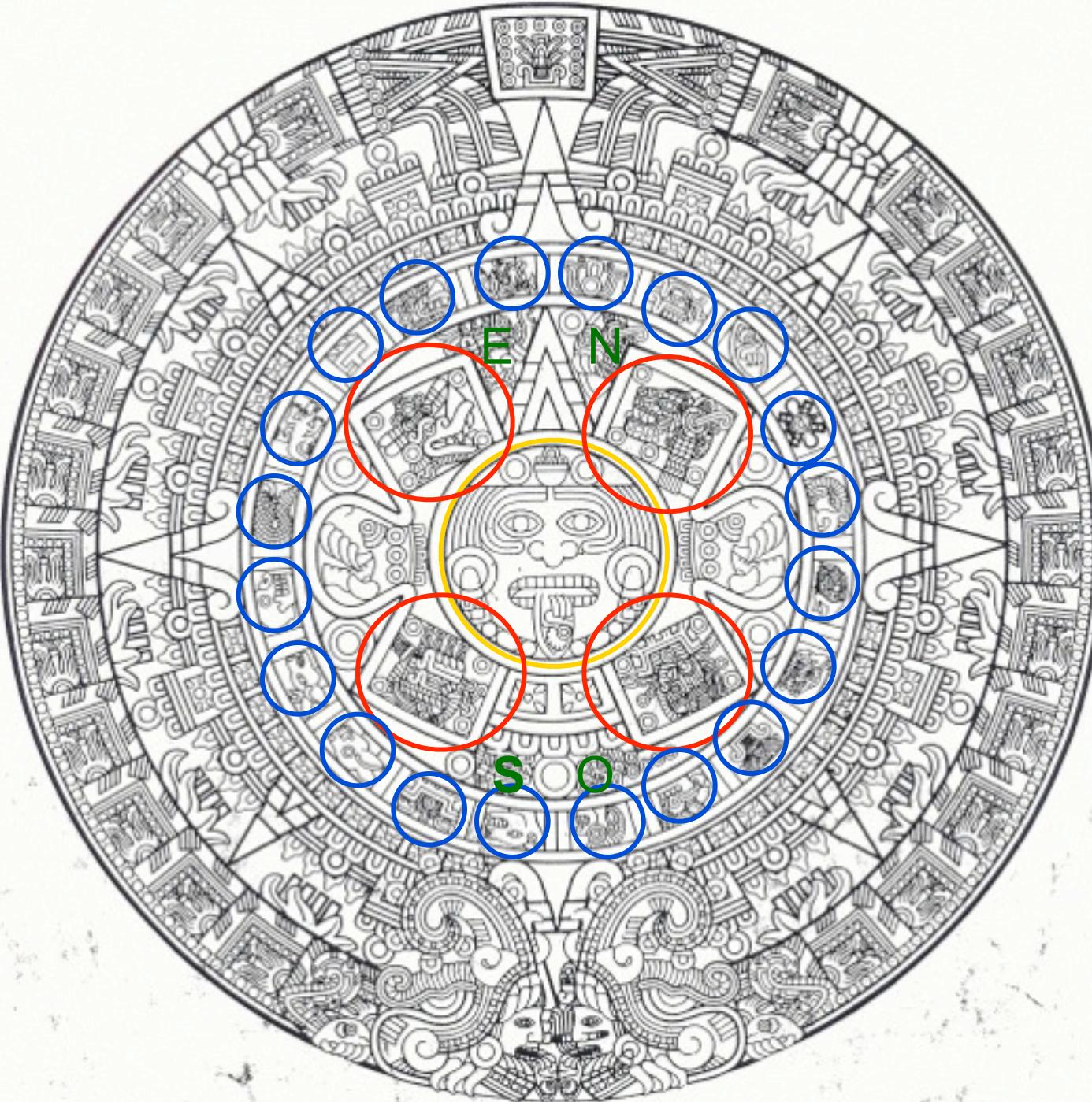
Humans turned to monkeys to  
save it from hurricanes  
huracans.  
(woods)

3rd era

Humans turned to birds to save  
it from fire and lava's rain  
(volcanic terrain)

4th era

Humans converted to fishes to  
save it from the Flood  
(fossils)



1st era

Giants attacked by jaguars.  
(dinosaures)

2nd era

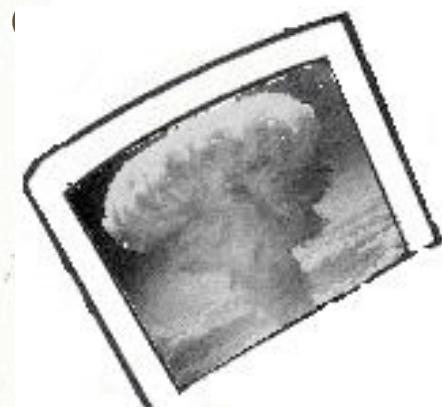
Humans turned to monkeys to  
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(woods)

3rd era

Humans turned to birds to save  
it from fire and lava's rain  
(volcanic terrain)

4th era

Humans converted to fishes to  
save it from the Flood



# Atic calendar

- Month begin with new moon
- Year begins with autumn equinox
- $1y = 6 \text{ m of } 29\text{d} \& 6\text{m of } 30\text{d} = 354\text{d}$
- Octateric cicles: every 8y: 3rd, 5th & 8th years of 13 months (13 month of 30d)

1	12 months
2	12 months
3	13 months
4	12 months
5	13 months
6	12 months
7	12 months
8	13 months

## Embolistic years

- Left 2 days every 8 years

# Helenic calendar

- Begins with the first olympiad

1st olympiad = 776BC

1st year of the 2nd olympiad

2nd year of the 2nd olympiad

3rd year of the 2nd olympiad

2nd olympiad

1st year of the 3rd olympiad

...

696 olympiad = 2005AD

Countng stoped at the VI century AD

# Chinese calendar

- Since 10th March 2697 BC: Huang Di
- 1y = 6m of 30d & 6m of 29d = 354d
- Years begin in the 2nd full moon after winter solstice
- Cycles of 19y where 3rd, 6th, 9th, 11th, 17th & 19th have 13m (embolismals), to adjust it to the solar one
- 5 cycles of 12y, each one with an animal name (astrology)

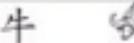
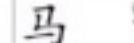
Shu (Rat)	Ma (Horse)
Niu (Buffalo)	Hou (Monkey)
Hu (Tiger)	Gou (Dog)
Mao (Cat)	Zhu (Pig)
Long (Dragon)	Ji (Cock)
She (Snake)	Xang (Goat)

# Japanese calendar

- Begins 18th February 660BC (Japan foundation)

# Siamese calendar

- 3 eras:
  - 658aC: PLUITTHA-SAKHRAT (Budica)
  - 544aC: PHRA-RUANG (Antiga)
  - 1782dC: RATANOKOSIN (Bangkok)

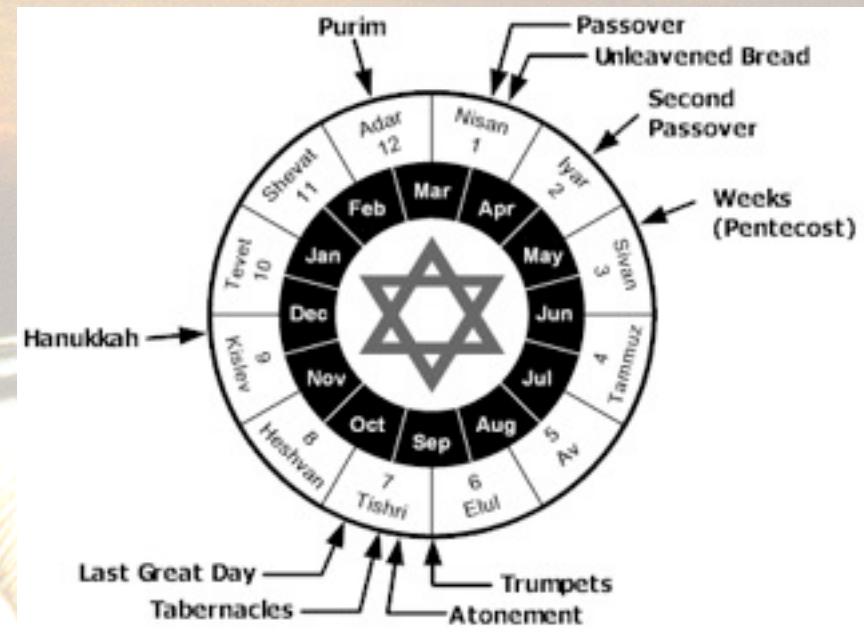
<b>鼠</b>  Year of the Rat 1972, 1984, 1996, 2008 Rat people are very popular. They like to invent things and are good artists.	<b>牛</b>  Year of the Ox 1973, 1985, 1997, 2009 People born in this year are dependable and calm. They are good listeners and have very strong ideas.	<b>虎</b>  Year of the Tiger 1974, 1986, 1998, 2010 Tiger people are brave. Other people respect tiger people for their deep thoughts and courageous actions.	<b>兔</b>  Year of the Rabbit 1975, 1987, 1999, 2011 People born in this year are nice to be around. They like to talk, and many people trust them.
<b>龙</b>  Year of the Dragon 1976, 1988, 2000, 2012 Dragon people have good health and lots of energy. They are good friends because they listen carefully to others.	<b>蛇</b>  Year of the Snake 1977, 1989, 2001 People born in this year love good books, food, music, and plays. They will have good luck with money.	<b>马</b>  Year of the Horse 1978, 1990, 2002 People born in this year are popular, cheerful, and are quick to compliment others. Horse people can work very hard.	<b>羊</b>  Year of the Goat 1979, 1991, 2003 People born in this year are very good artists. They ask many questions, like nice things, and are very wise.
<b>猴</b>  Year of the Monkey 1980, 1992, 2004 Monkey people are very funny. They can always make people laugh. They are also very good problem solvers.	<b>鸡</b>  Year of the Rooster 1981, 1993, 2005 People born in this year are hard workers. They have many talents and think deep thoughts.	<b>狗</b>  Year of the Dog 1982, 1994, 2006 Dog people are loyal and can always keep a secret. Sometimes dog people worry too much.	<b>猪</b>  Year of the Pig 1983, 1995, 2007 People born in this year are very good students. They are honest and kind. They always finish a project or assignment.

# Hebrew calendar

- Lunisolar (similar to chinese)
- $1y = 12m$  of 29 or 30d = 354d
- It's delayed 11d every year. A month is added when the difference between tropic and hebrew is more than 30d (cada 2 o 3 anys)
- $19y = 235$  lunaciones (months)
  - Cicle de Meton: cada 19y, el 3, 6, 8, 11, 14, 17 i 19 tenen 13 mesos (embolismals)

# Jewish calendar

- Reform from Hebrew in the 11th century
- Began with the genesis of the world 1 Tishei of the year 1 (= 7th October of 3761BC)

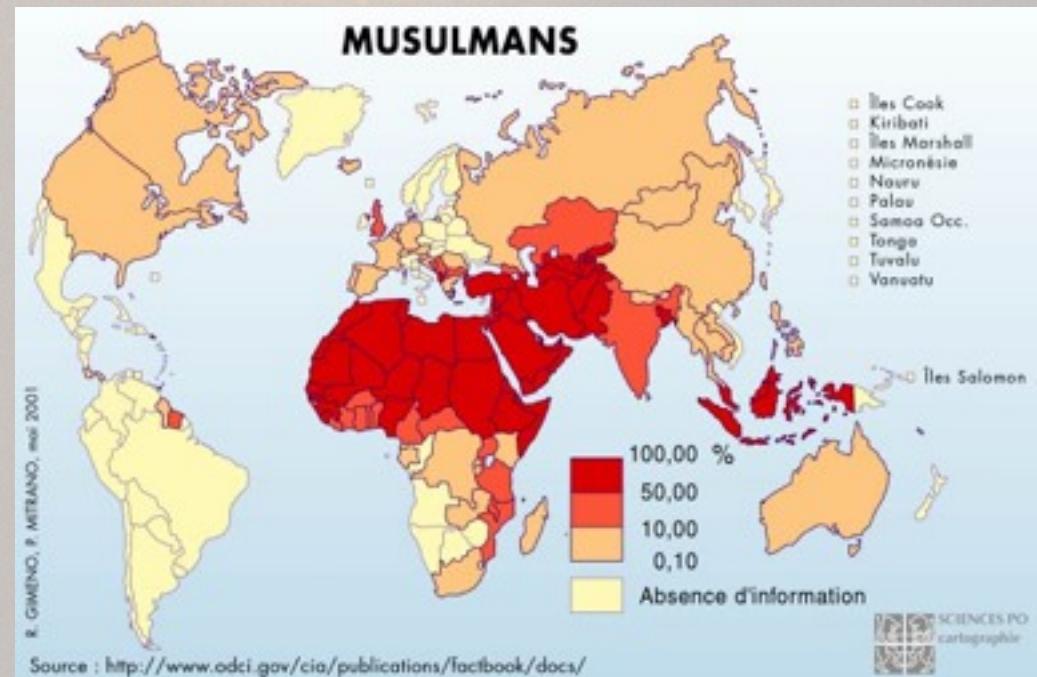


- The day started with the sunset

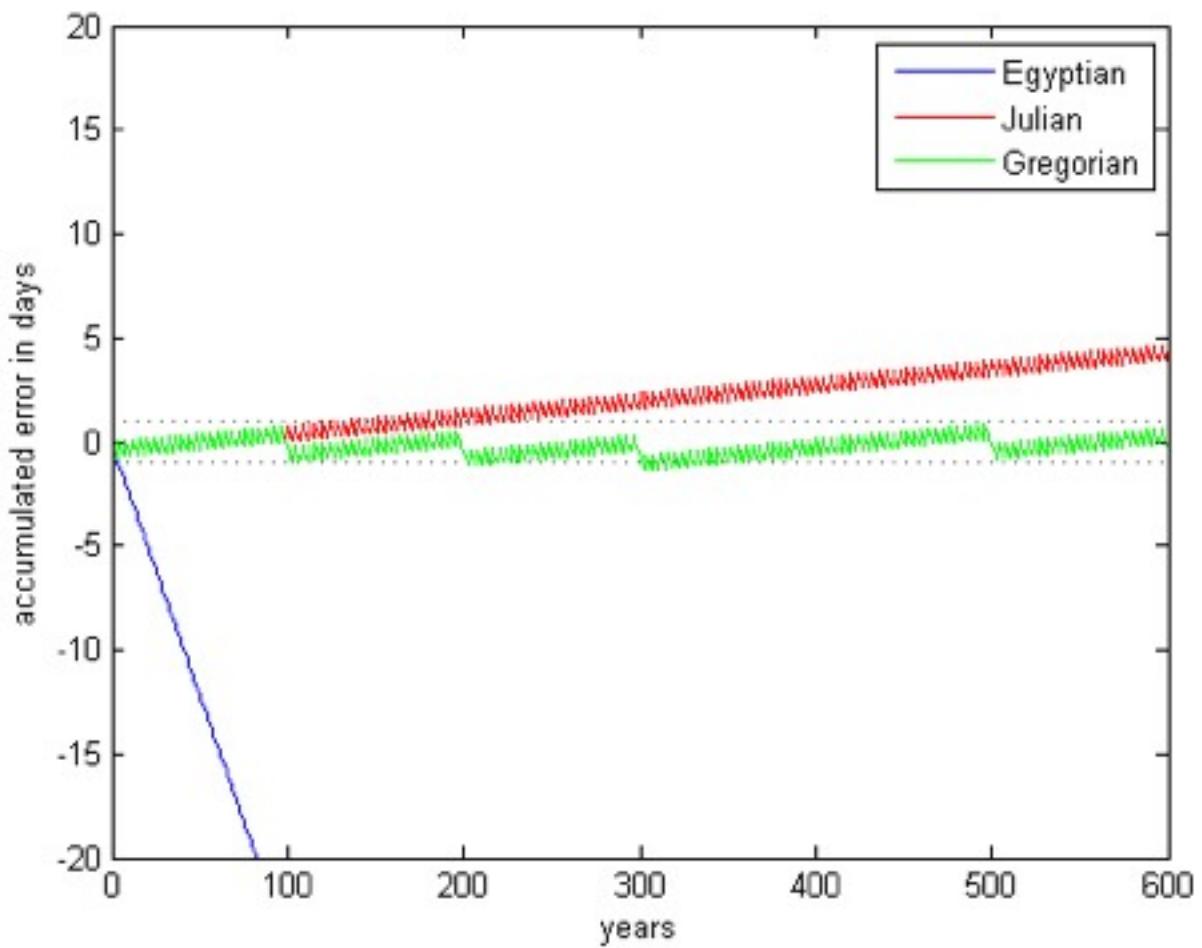
# Islamic calendar

- Lunar
- Cycles of 30y
  - $19y = 6m \text{ of } 30d \text{ & } 6m \text{ of } 29d = 354d$  (SIMPLES)
  - $11y = 7m \text{ of } 30d \text{ & } 5m \text{ of } 29d = 355d$  (ALTERNATE)
- Began the 16th of July 622AD (the Prophet Mohammed moved to Mecca and founded the first islam community in Mecca)
- The day began with the sunset
- The month began with the new moon

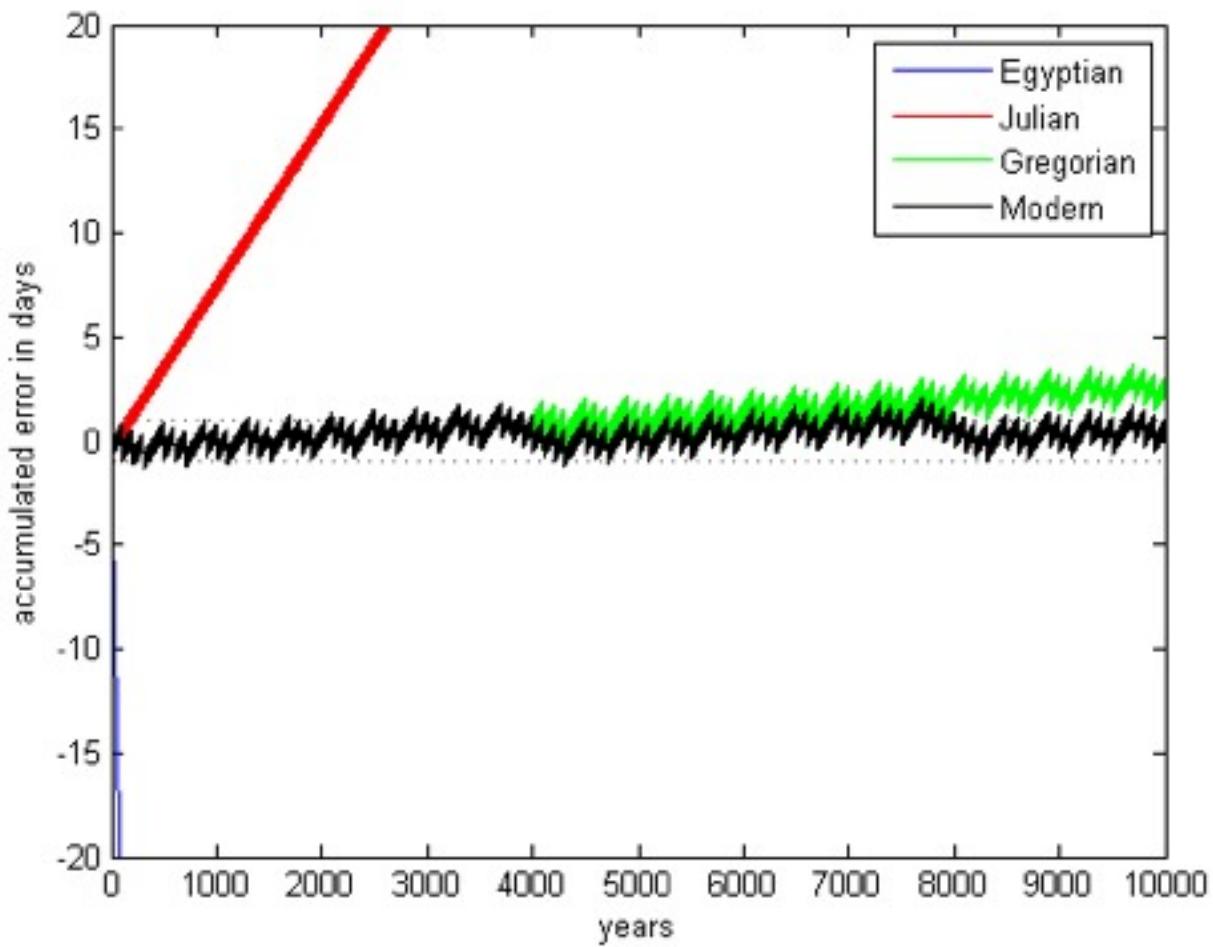
$$H = G - 622 + (G - 622)/32$$



# Precision



# Precision



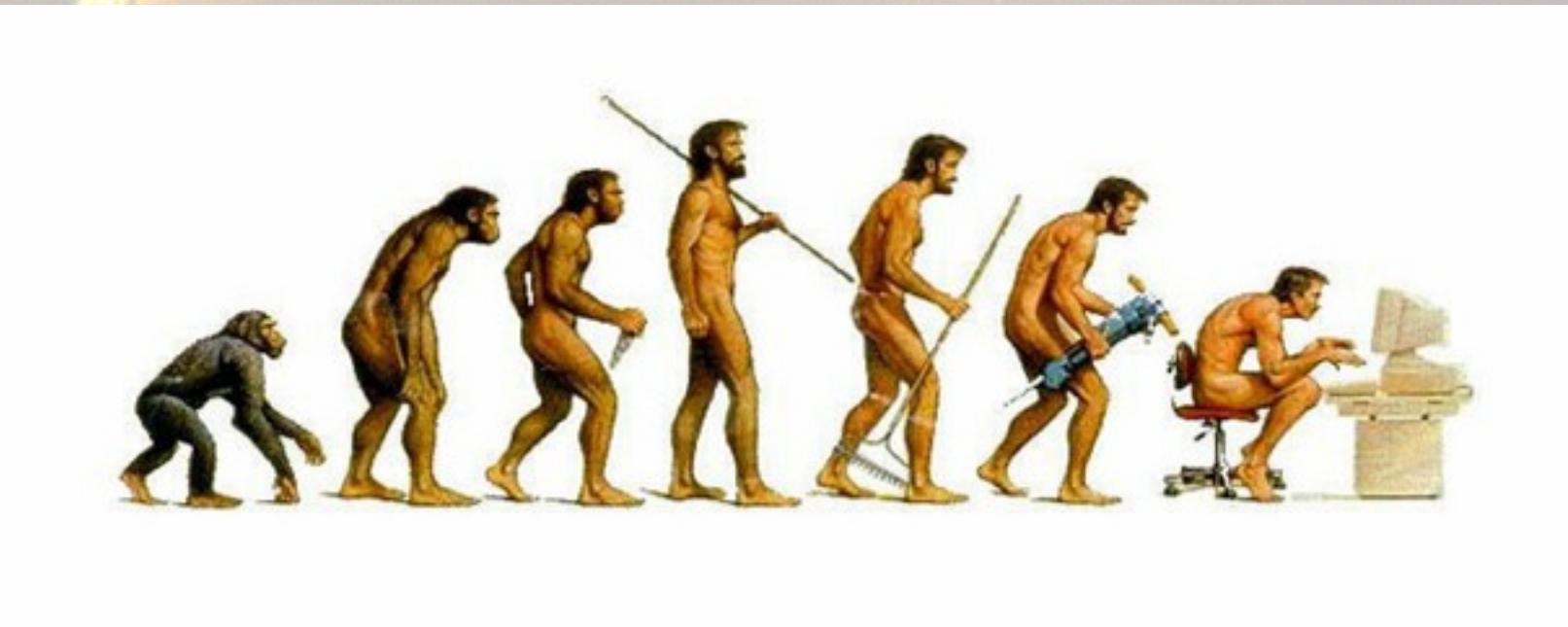
# *Beginning of time??*

Day of the agreement

HUMAN RACE

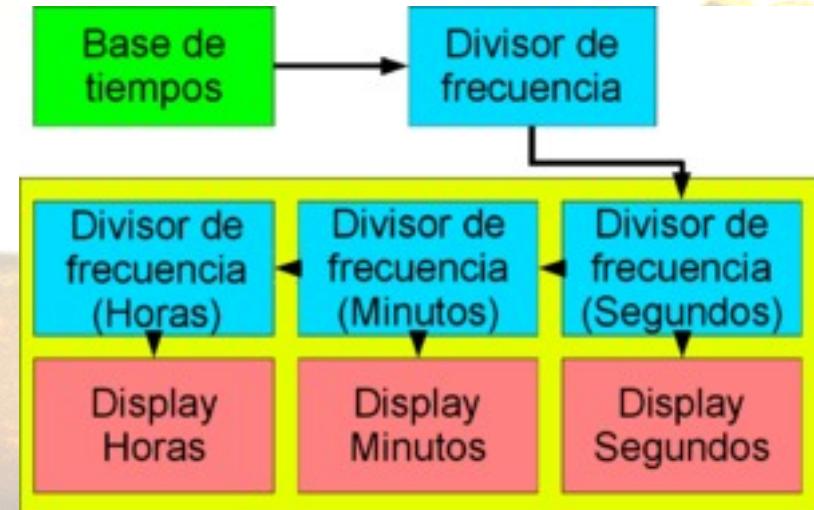
EARTH

BIG BANG??



# Watches

- Sun - water
- sand
- pendulus
- Electronic: There are some counters which divide the oscillator frequency to 1Hz (seconds)
  - Quartz: 32768Hz oscillator
  - Atomic: atomic vibration frequency

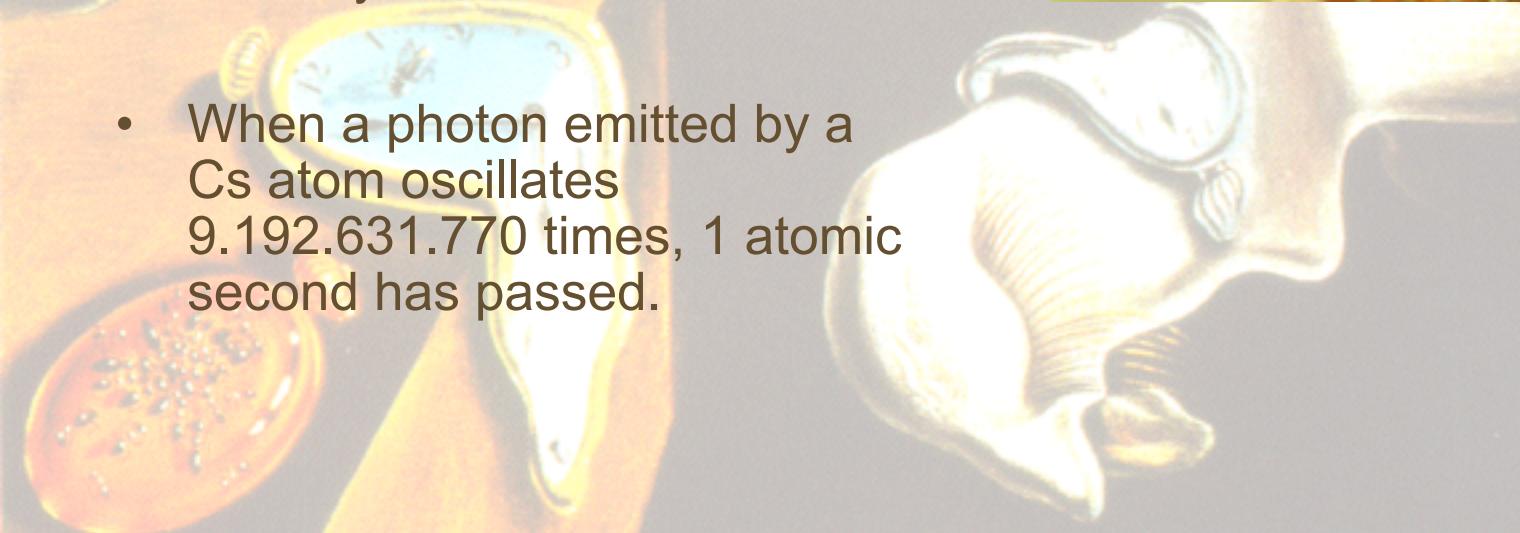
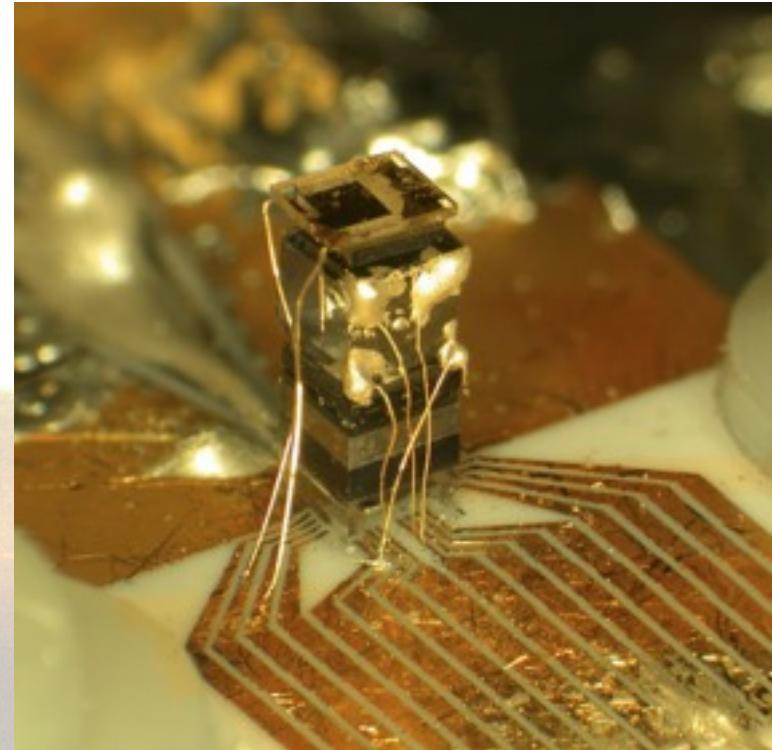


Until 1967 we defined the second as the 86400th part of the average solar day between 1750 and 1890

Nowadays the second is currently defined as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.

# Atomic watch

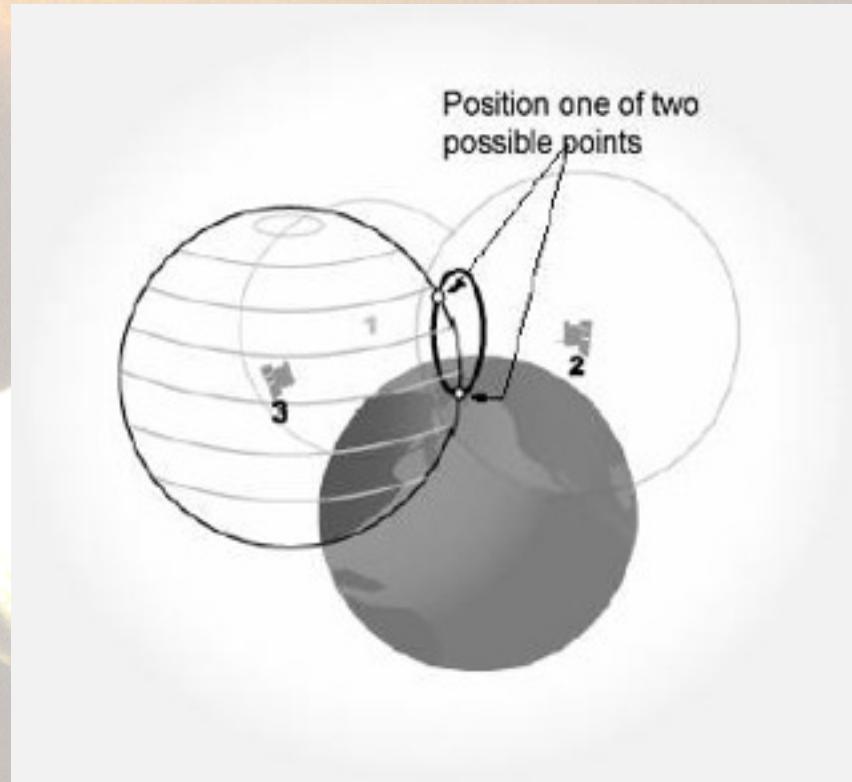
- MASER
- Built for the first time in 1949 in the USA. Made of amoniac
- Nowadays watches are made of  $^{133}\text{Cs}$  (1955, UK)
  - It is delayed 1s every 30000y
- The most precise is located in Paris. It is delayed 1s every 52 million years
- When a photon emitted by a Cs atom oscillates 9.192.631.770 times, 1 atomic second has passed.



# GPS

**NAVSTAR GPS (NAVigation Satellite  
Timing And Ranging Global Positioning  
System)**

- 24 satellites
- C/A
- Receptor imitates
- 4 satellites
- trilateration



# *Summary & Conclusions*

- Humanity always have had the need to date and to put in order. To predict natural cycles and to put in order important events.
- Improving our methods we are able to invent devices that, in principle, are not related to measuring time

$41^{\circ}30'03,54''\text{N}$

$2^{\circ}06'35,85''\text{E}$

Mapa

Satélite

Hí

