



# “La sublime utilidad de la ciencia inútil”

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Zarautz

2023ko urriaren 24a



“La respuesta es la  
**ignorancia**. El  
remedio es todavía  
desconocido”

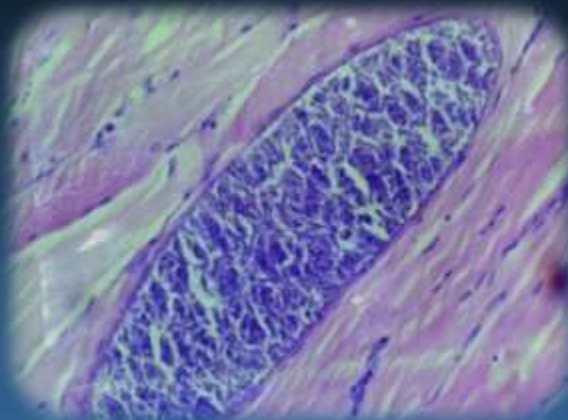
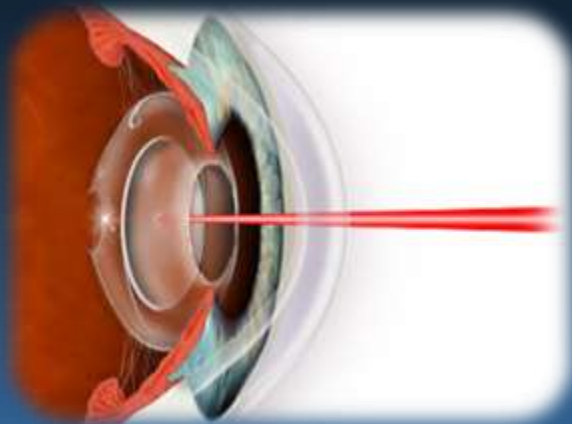
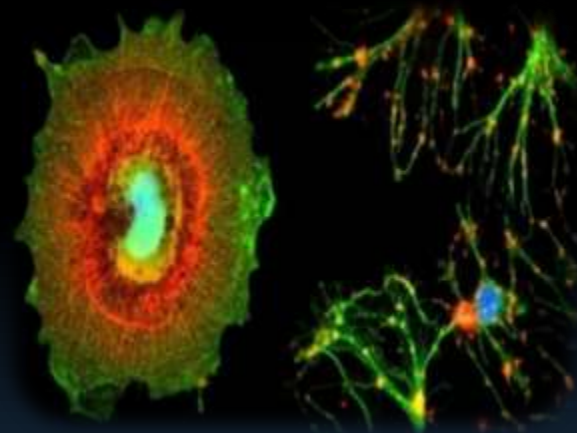
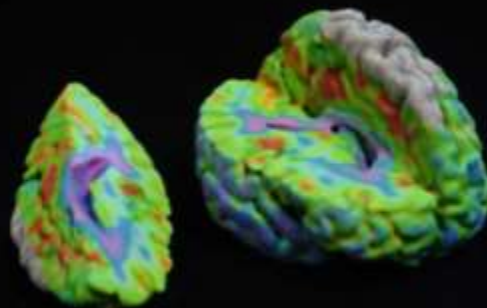
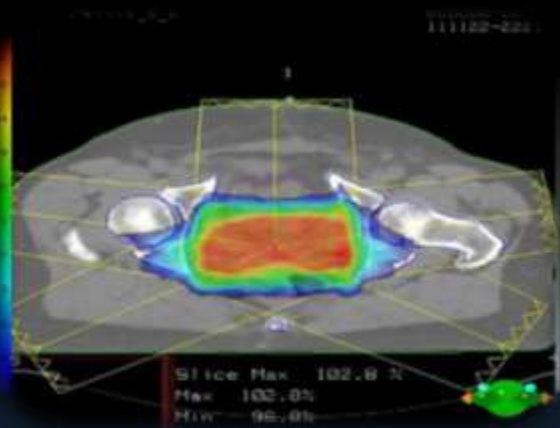
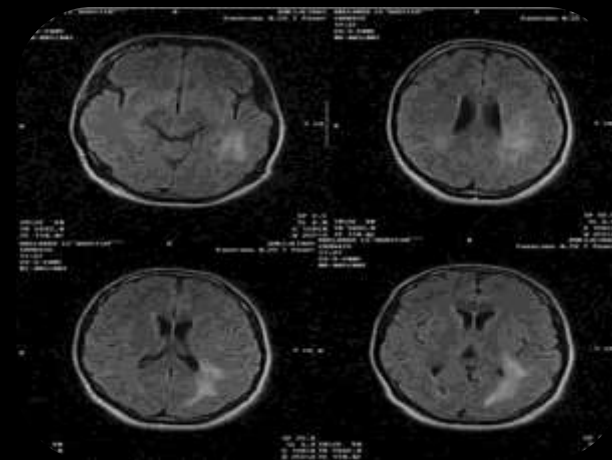
-1899-

**Henry A. Rowland**

1<sup>er</sup> Presidente de la Sociedad  
de Física Americana









"Éste que veis aquí, de rostro aguileño, de cabello castaño, frente lisa y desembarazada, de alegres ojos y de nariz corva, aunque bien proporcionada; las barbas de plata, que no ha veinte años que fueron de oro, los bigotes grandes, la boca pequeña, los dientes ni menudos ni crecidos, porque no tiene sino seis, y éstos mal acondicionados y peor puestos, porque no tienen correspondencia los unos con los otros..."

Cervantes  
Prólogo de las Novelas Ejemplares (1613)

**Progreso**

# Vivimos más

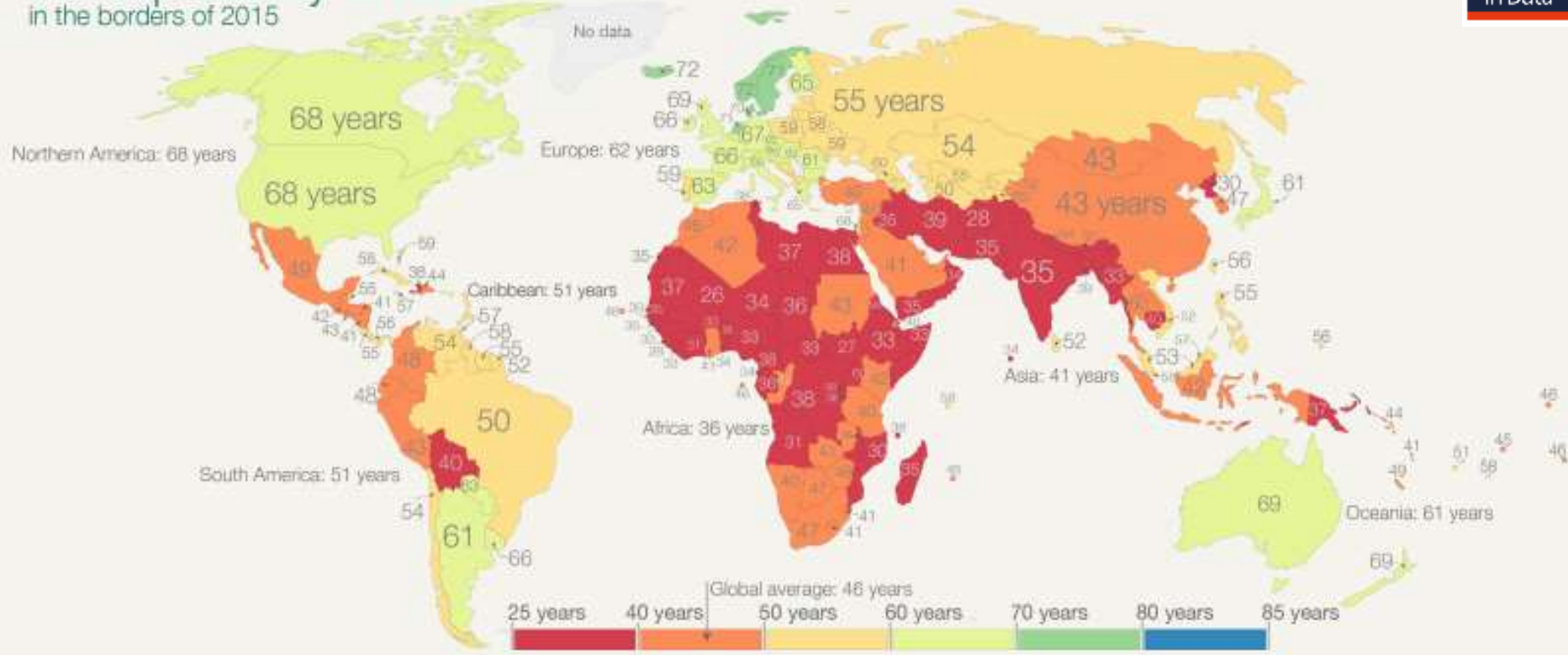
## Life expectancy in 1800 in the borders of 2015



- Historical estimates suggest that up to at least the year 1800 the life expectancy for people in all countries was less than 40 years.  
- These historical estimates come with substantial uncertainty.

# Vivimos más

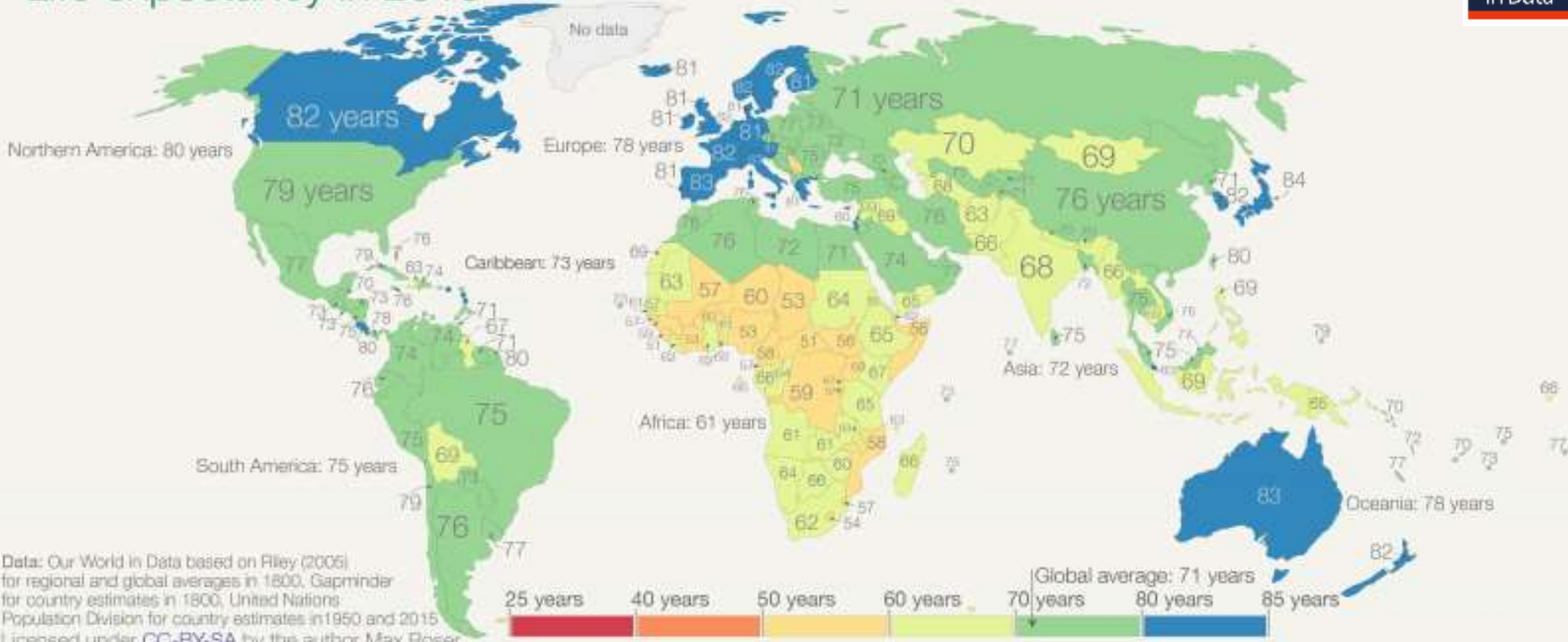
Life expectancy in 1950  
in the borders of 2015





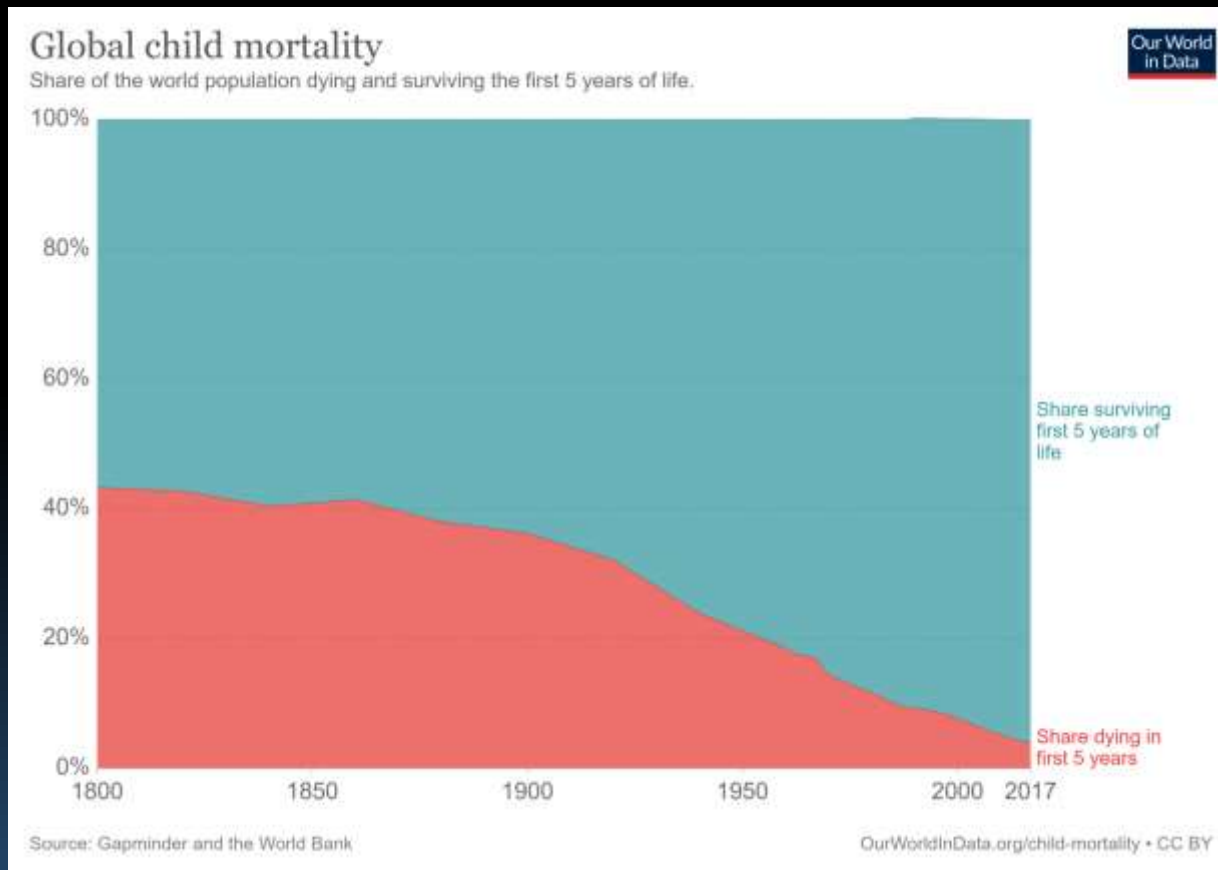
# Vivimos más

## Life expectancy in 2015



Data: Our World in Data based on Riley (2006) for regional and global averages in 1800. Gapminder for country estimates in 1800. United Nations Population Division for country estimates in 1950 and 2015. Licensed under CC-BY-SA by the author Max Roser.

# Vivimos más

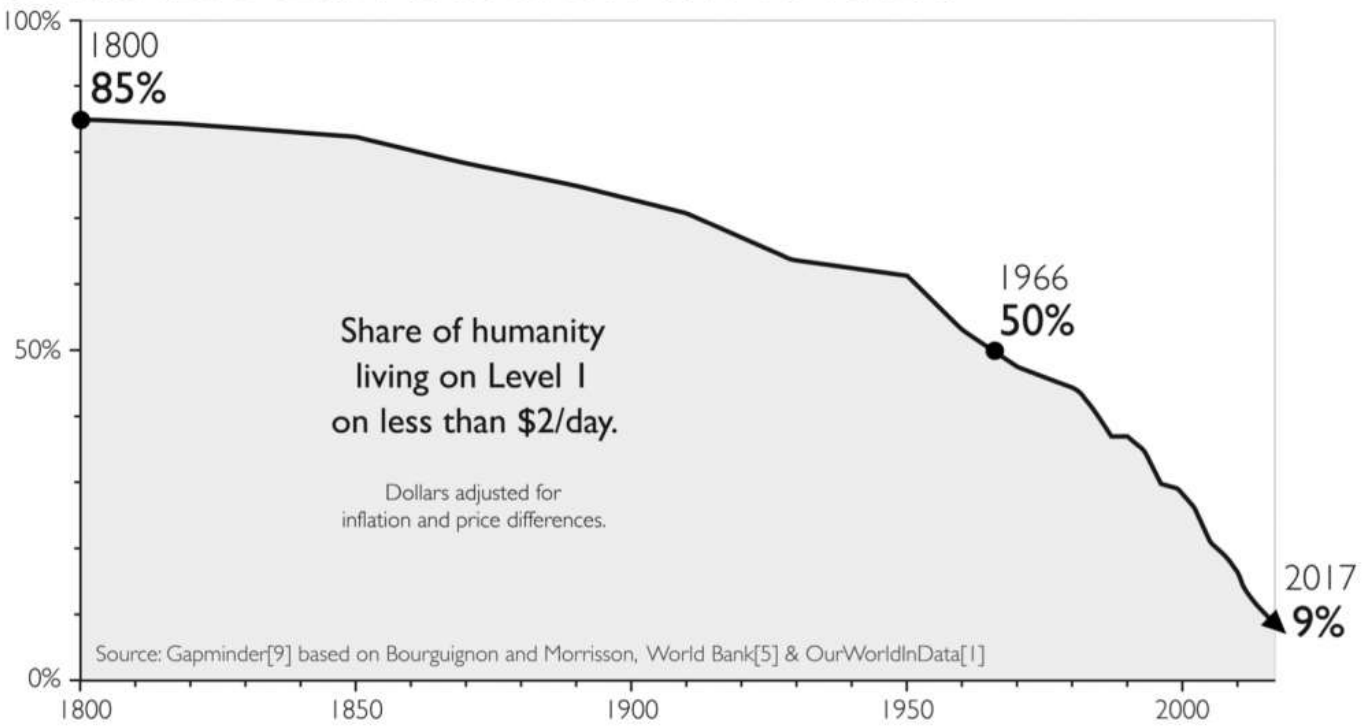


**“no hay duda, lo más poético,  
más poético que las flores y más  
que las estrellas,  
es no enfermar”**

**Chesterton**

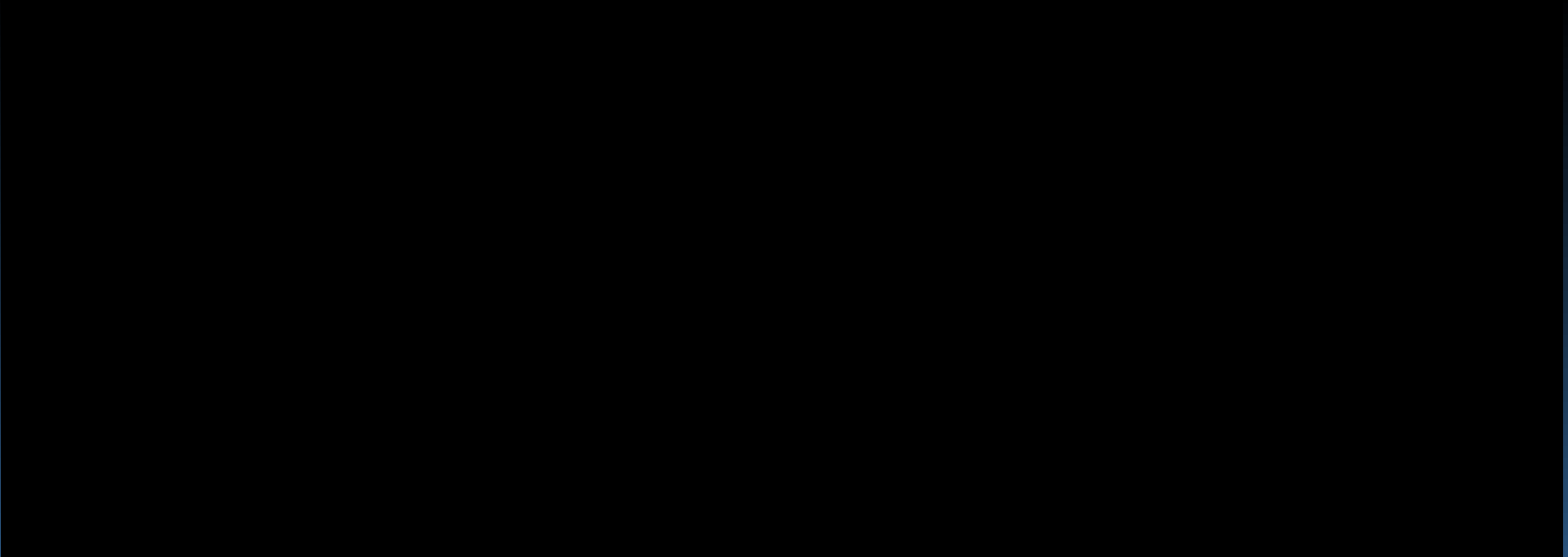
# Vivimos mejor

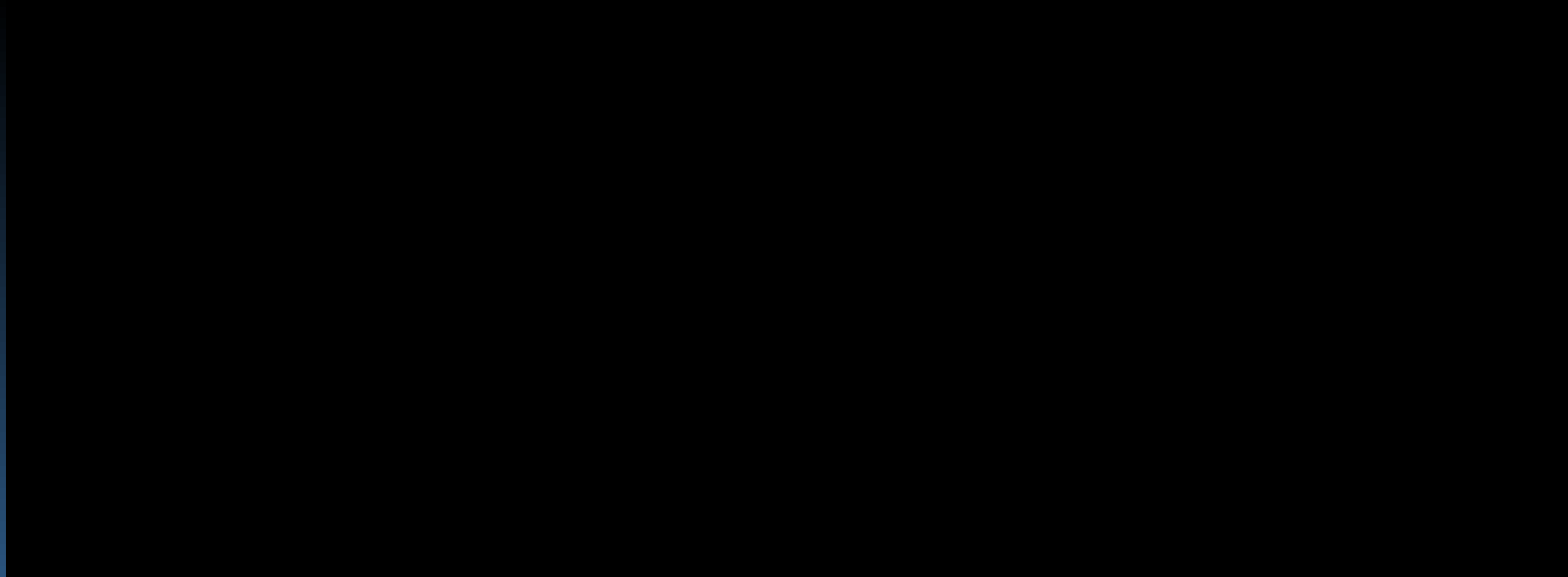
## EXTREME POVERTY RATE FROM 1800 TO TODAY



**What is science?**

**Experiment- Nullius in verba**

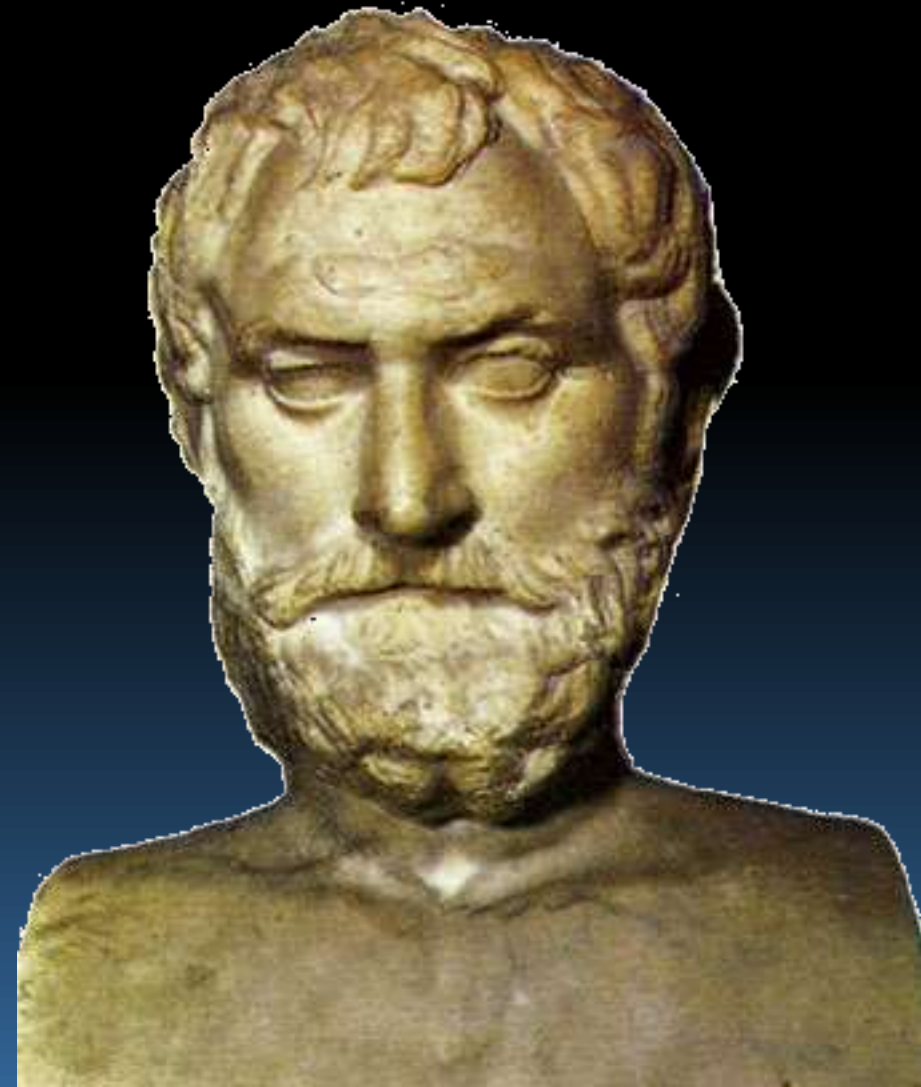


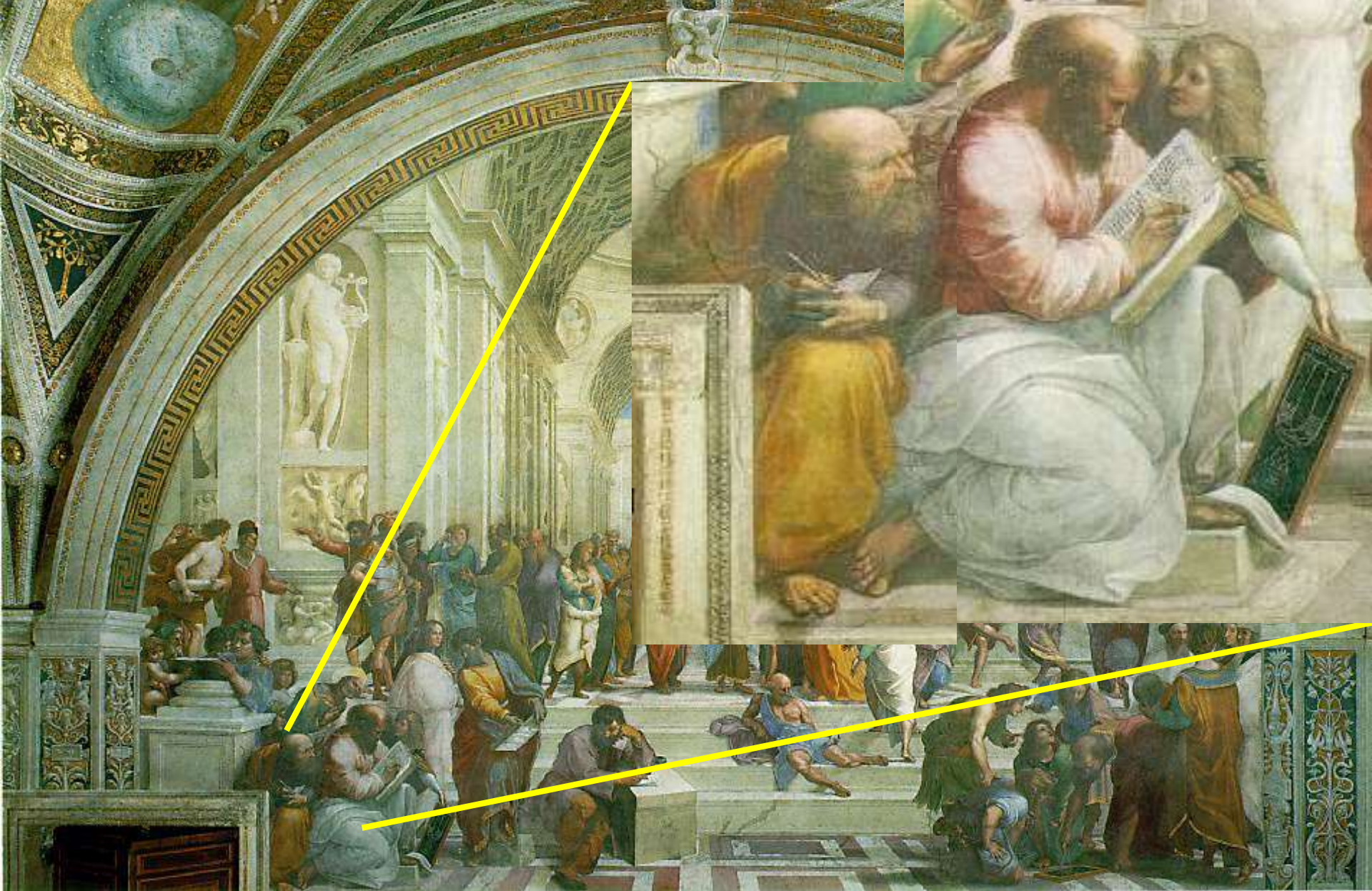


**Science is Greek**



# Encantamiento jónico





Empédocles, Pitágoras, Anaxágoras  
(Escuela de Atenas, de Rafael)

# LECCIONES DE LOS PENSADORES GRIEGOS

- *racionalidad*
- *matematización*
- *análisis de "interiores" de las cosas, en busca de sus constituyentes últimos*
- *síntesis teórica, propuesta de principios básicos*



**Science is culture**

The conceptual structure of  
**Science** is the most important  
collective cultural work of mankind,

the most beautiful collective work  
of art of mankind

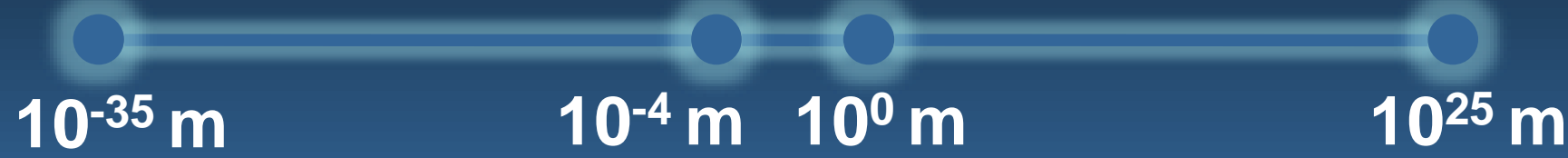
**CULTURE**

# Wissenschaft und Bewusstsein (Bildung und Werte)



“Die Wissenschaft ist an die Stelle der Metaphysik getreten. Fragen, so alt wie die was der Ursprung des Universums ist oder woraus Materie gemacht ist, werden in den grossen Laboratorien angegangen. (...) Die Wissenschaftler erfinden neue Weltbilder, grandiose Metaphern wie Schwarze Loecher oder Elementarteilchen. Die scharfe Trennung zwischen Wissenschaft und Literatur, die es noch im 19. Jahrhundert gab, existiert nicht mehr”

Hans Magnus Ezensberger



$10^{-35}$  m

$10^{-4}$  m

$10^0$  m

$10^{25}$  m

# The Big Bang

## PHYSICS

Chemistry starts  
around here

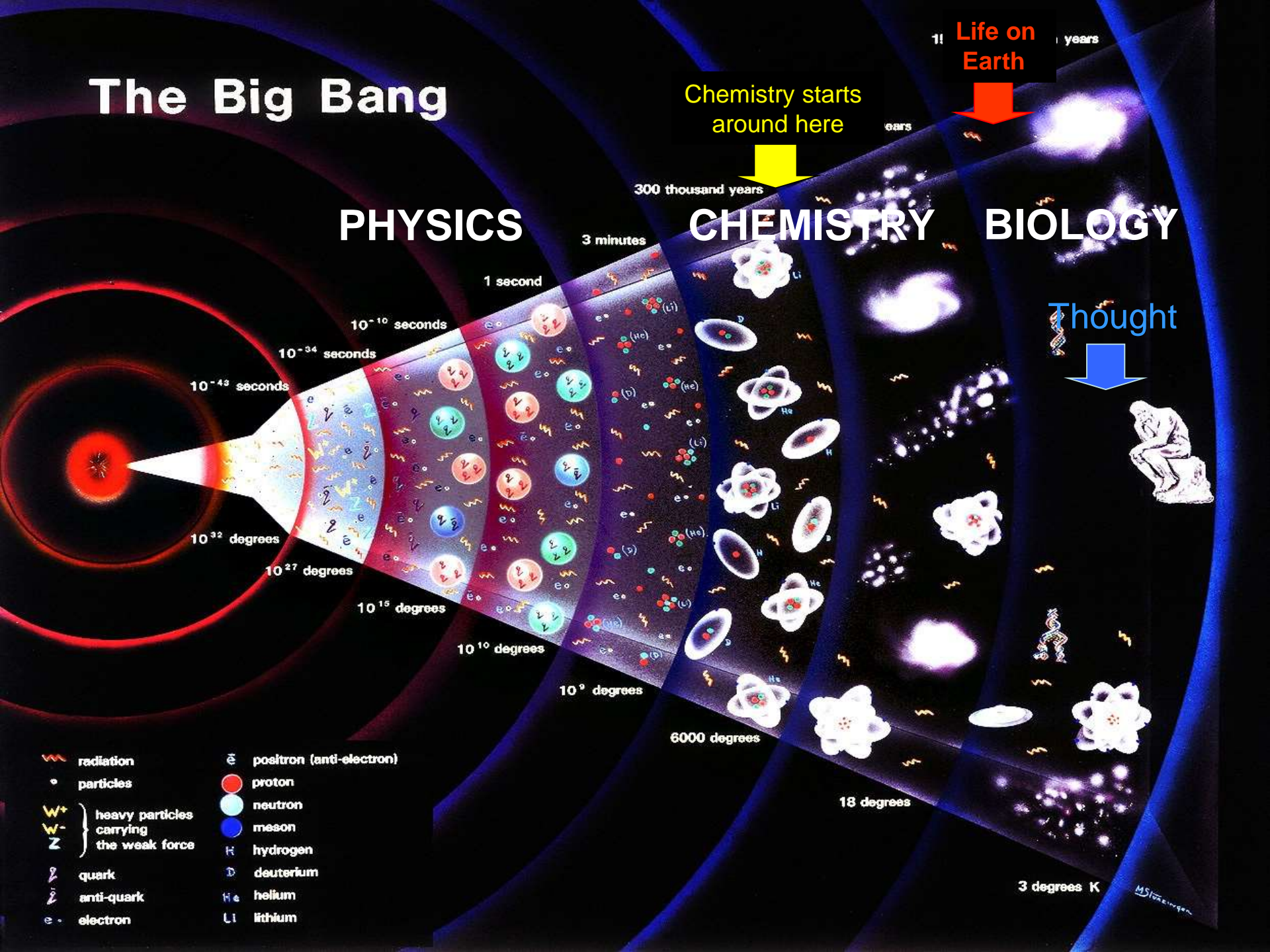
Life on Earth  
years

## CHEMISTRY

## BIOLOGY

Thought

- radiation
- particles
- $W^+$  } heavy particles carrying the weak force
- $W^-$  }
- $Z$  }
- quark
- anti-quark
- $e^-$  electron
- $e^+$  positron (anti-electron)
- proton
- neutron
- meson
- $H$  hydrogen
- $D$  deuterium
- $He$  helium
- $Li$  lithium

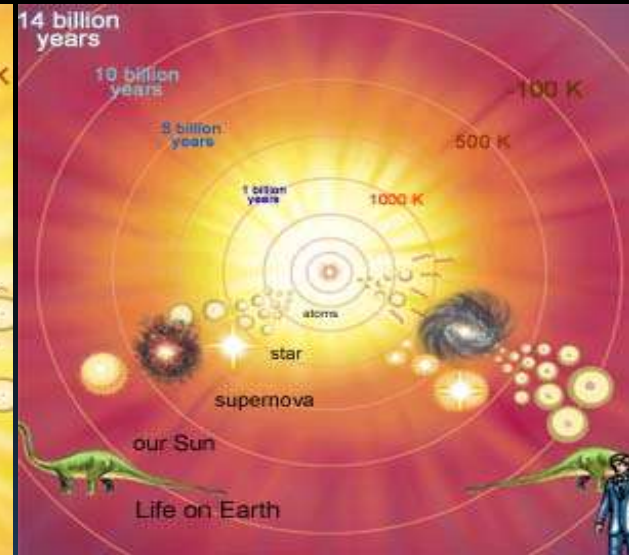
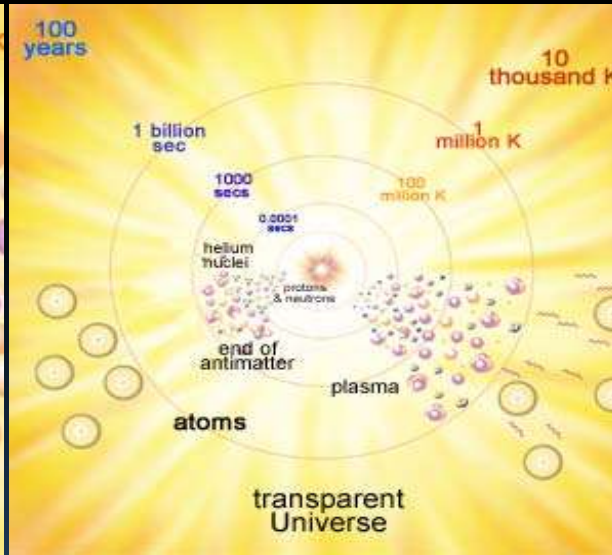
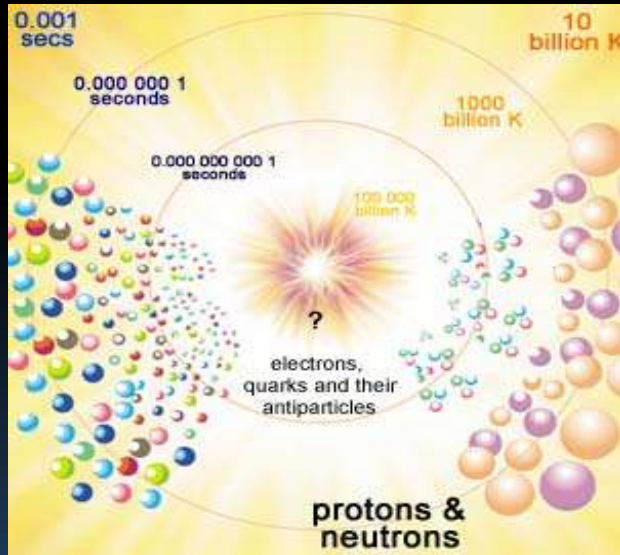
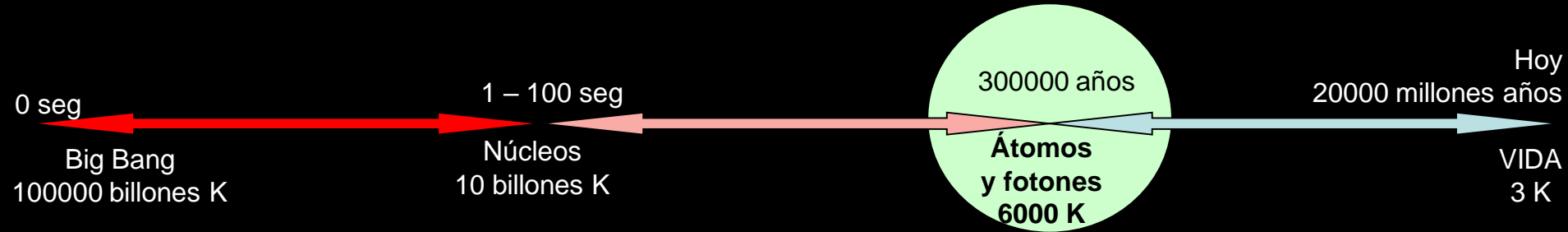


MSKunzinger



# Historia del Universo

## Aparición de los átomos



# The Cosmic Calendar

The 13.8 billion year history of the universe scaled down to a single year, where the Big Bang is January 1<sup>st</sup> at midnight, and right now is midnight 1 year later

January	February	March	April	May	June	July	August	September	October	November	December
<p><i>Known from telescopes looking back in time, physical models</i></p>								<p><i>Known from geologic record, fossils, genetic drift</i></p>			
The Big Bang, Stars First Appear				Thin Disk of the Milky Way				The Solar System, Life	Oxygen from Photosynthesis	Eukaryotic Cells	Multicellular Life

## The Month of December...

1	2	3	4	5	6	7	8	9	10	11	12	13	14
15 Trace Fossils Only	16	17 Bones and Shells	18 Vertebrates	19 Land Plants	20 Fish with Jaws	21 Insects							
22 Amphibians	23 Reptiles	24 Pangaëa Forms	25 Dinosaurs	26 Mammals	27 Birds	28 Flowers							
29 Tyrannosaurids	30 Dinosaurs Extinct, Mammals Take Over on Land and in Sea	31 The Final Day...											
		Dawn: Apes and Monkeys Split	8 PM: Humans and Chimpanzees Split	9:25: Humans First Walk Upright	10:30: Human Brain Size Begins Tripling	11:52: Modern Humans Evolve	11:56 to 11:59: Human Migration						

## The Final Minute...

A human life only lasts for the blink of an eye on the Cosmic Calendar:  $100 \text{ years} * 365 * 24 * 60 * 60 / 13,800,000,000 = 0.23 \text{ Cosmic Seconds}$



# LA HISTORIA DEL COSMOS EN UN AÑO

Enero	Febrero	Marzo	Abril	Mayo	Junio
13,8 mil millones de años 				11 mil millones de años 	

Big Bang

Nace la Vía Láctea

Julio	Agosto	Septiembre	Octubre	Noviembre
	4,5 mil millones de años 	3,5 mil millones de años 	2,3 mil millones de años 	2 mil millones de años 

Nace el sistema solar Primeras formas de vida Oxígeno de la fotosíntesis Células complejas

# Diciembre

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18		20	21
22	23	24		26	27	28
29		30	31	EL ÚLTIMO MES...		



## EL ÚLTIMO DÍA...

22.30.00      Primeros seres humanos

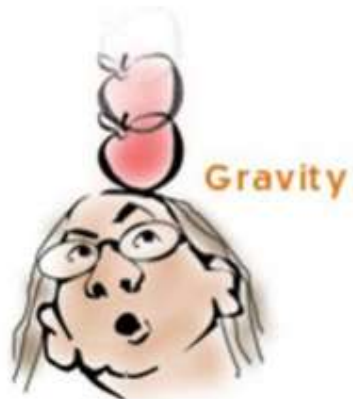
## EL ÚLTIMO MINUTO ...

23.59.00      Pintura rupestre

23.59.30      Neolítico

23.59.53      Guerra Troya

23.59.55      TODA LA CIENCIA



Los constituyentes últimos de la materia son muy pocos y obedecen a leyes de gran simetría.



**Electromagnetismo**



**Nuclear débil**



**Nuclear fuerte**



**Gravitatoria**

**Electrodébil**

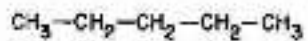
**Modelo estándar**



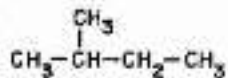
**El mundo de las cosas es vasto, inmenso e infinitamente variado. Es inagotable. Porque son inagotables las posibilidades, tanto en el mundo inanimado de copos de nieve y galaxias, como en el animado de felinos y flores.**



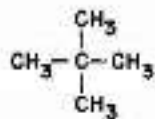




*n*-Pentane  
(bp = 36°C)



Isopentane  
(bp = 28°C)



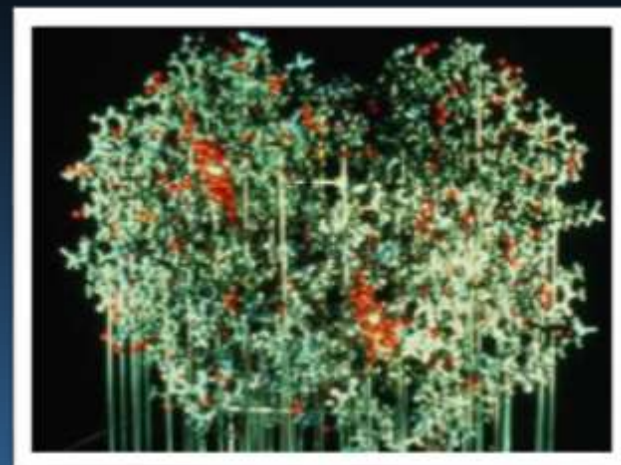
Neopentane  
(bp = 10°C)



$\text{C}_5 \text{H}_{12}$  three isomers of pentane

$\text{C}_{30} \text{H}_{62} \approx 4000$  million isomers

Think of Hemoglobin  $\text{C}_{2954} \text{H}_{4516} \text{N}_{780} \text{O}_{806} \text{S}_{12} \text{Fe}_4$ !!



Asymmetry



Complexity

European Policy

Economy

Sociology

Psychology

Fascinating by their complexity and richness

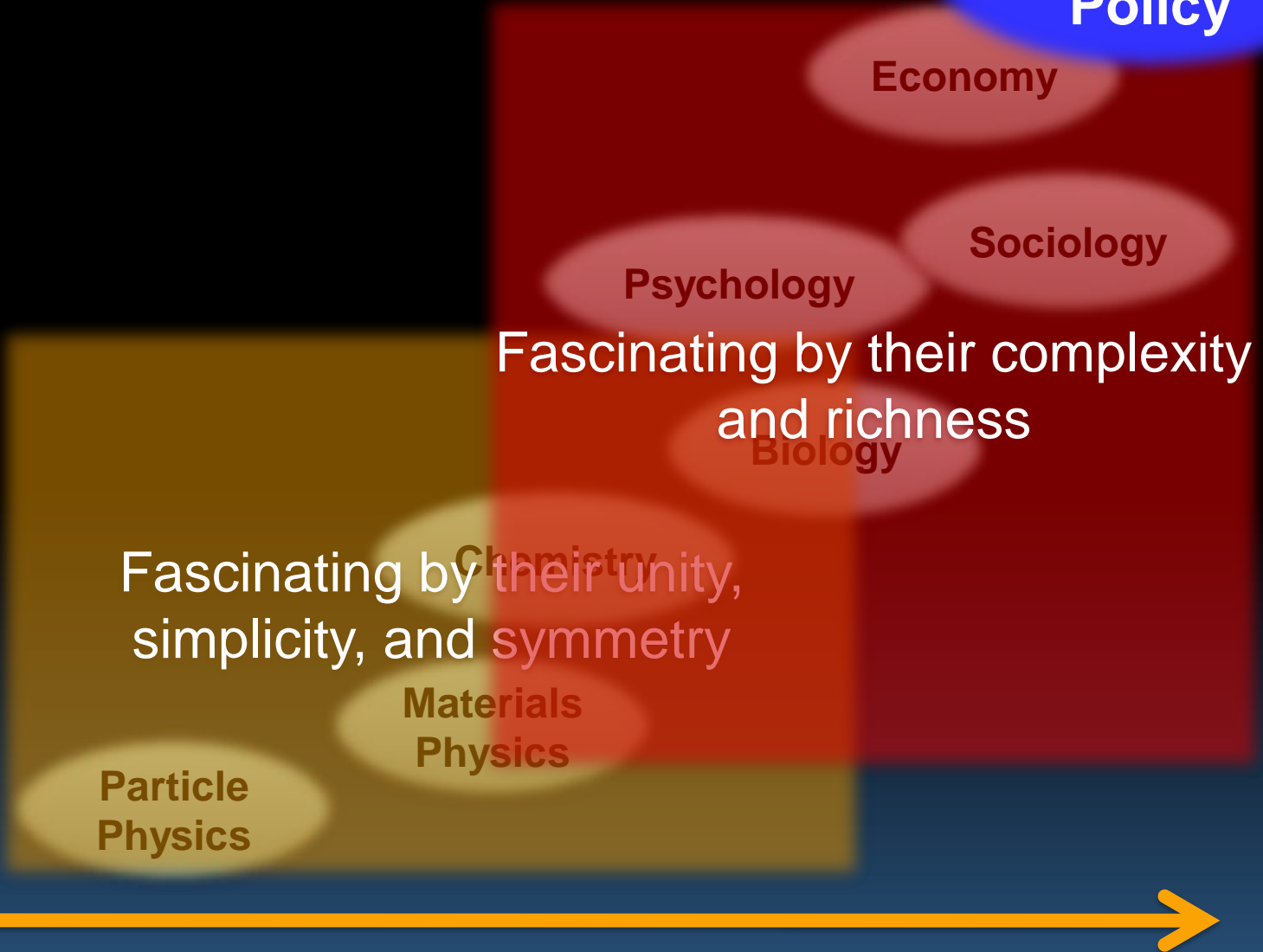
Biology

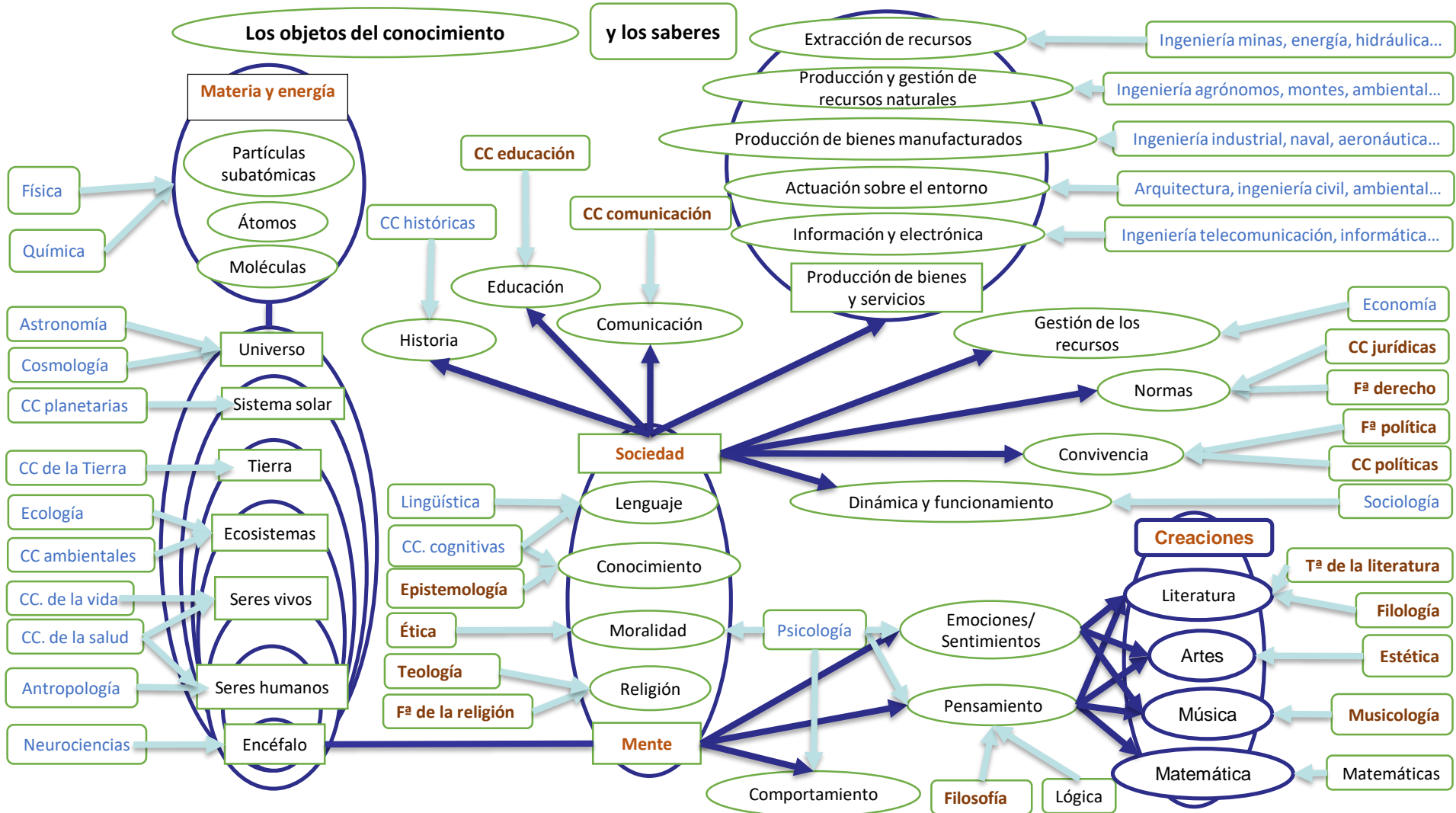
Fascinating by their unity, simplicity, and symmetry

Chemistry

Materials  
Physics

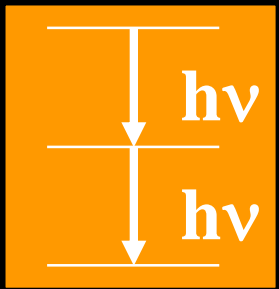
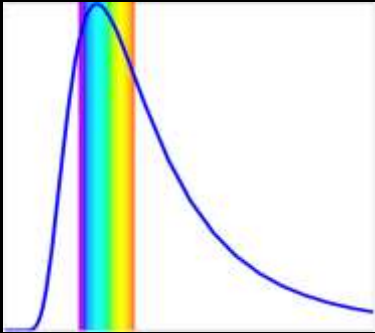
Particle  
Physics







Planck



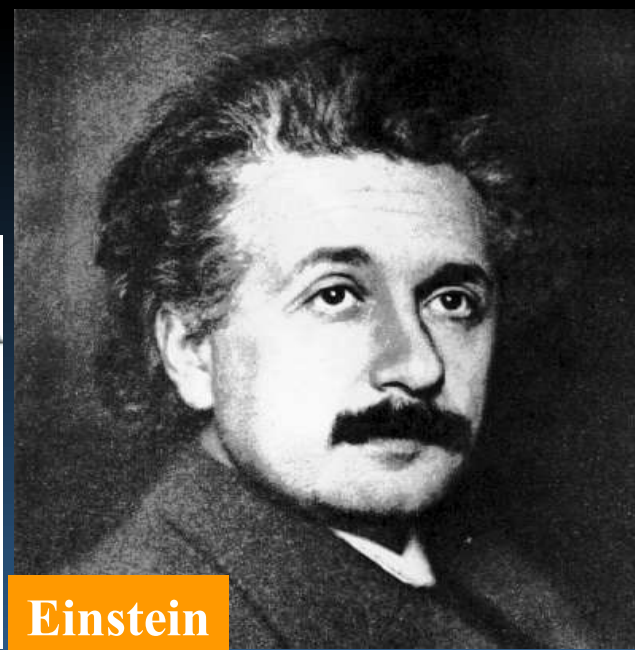
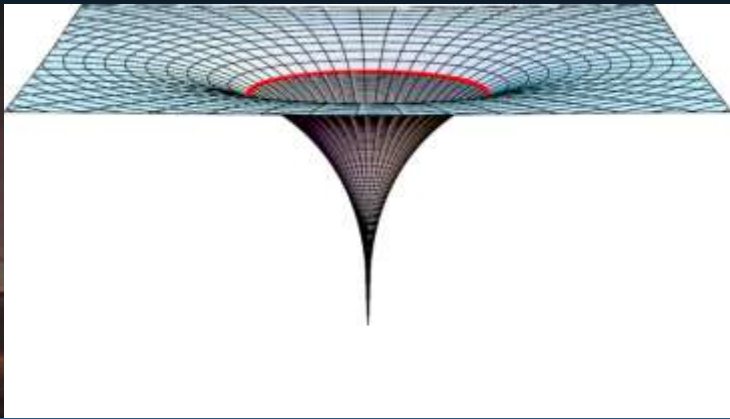
$$E = h\nu$$

Dos grandes revoluciones  
en el siglo XX:  
  
los Quanta  
y  
la Relatividad

$$E = mc^2$$



$$G_{\mu\nu} = \kappa T_{\mu\nu}$$



Einstein



Bohr



De Broglie



Heisenberg

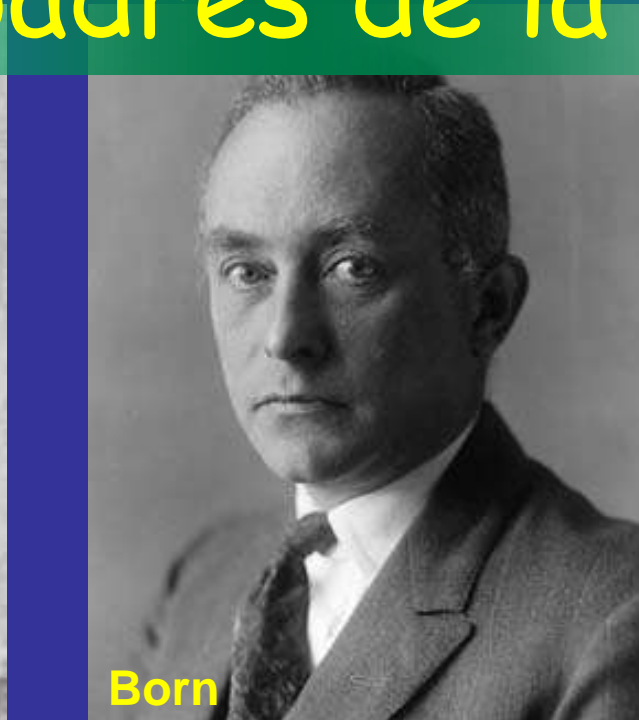


Dirac

# Los padres de la MQ



Schrödinger



Born



Pauli

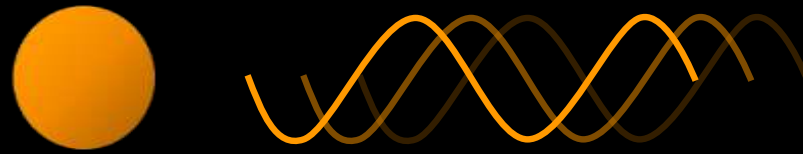
- Planck (1900)
- Einstein (1905)
- Niels (Henrik David) Bohr (1913)
- Louis (Victor Pierre Raymond, 7<sup>o</sup> Duque) de Broglie (1923)
- Werner Karl Heisenberg (1924)
- Wolfgang Pauli (1925)
- Erwin Schrödinger (1926)
- Max Born (1926)
- Paul (Adrien Maurice) Dirac (1928)

**Nueve genios sentaron en el primer cuarto del siglo XX las bases de la nueva física.**

- Planck (1918)
- Einstein (1921)
- Bohr (1922)

**Los nueve serían galardonados con el premio Nobel de Física:**

- De Broglie (1929)
- Heisenberg (1932)
- Pauli (1945)
- Schrödinger (1933)
- Max Born (1954)
- Dirac (1933)



**Dualidad onda-corpúsculo**



$$\Delta p \Delta x > h/2$$

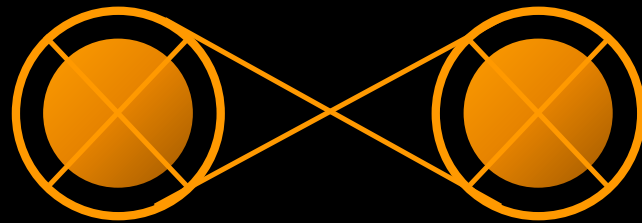
**Principio de  
incertidumbre**

# Schrödinger Cat

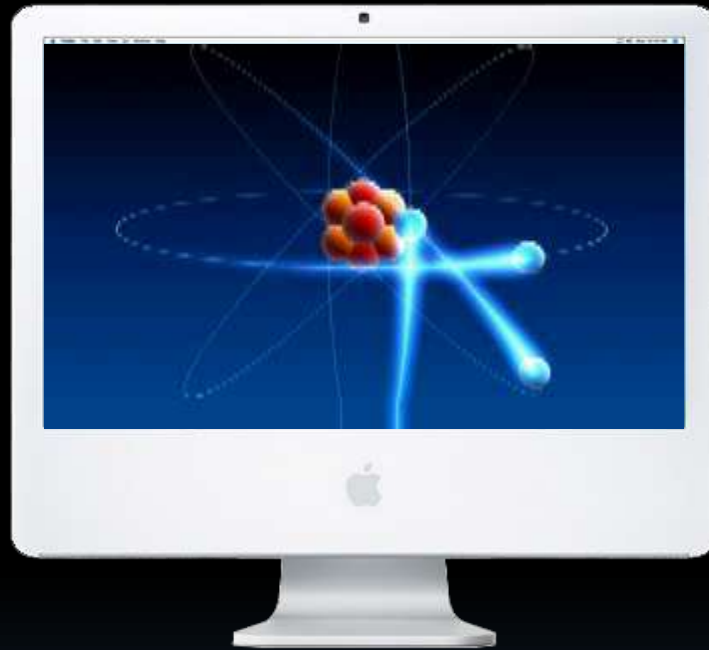


$$\psi_{\text{kitty}} = \frac{1}{\sqrt{2}} \psi_{\text{alive}} + \frac{1}{\sqrt{2}} \psi_{\text{dead}}$$

Superposition Principle



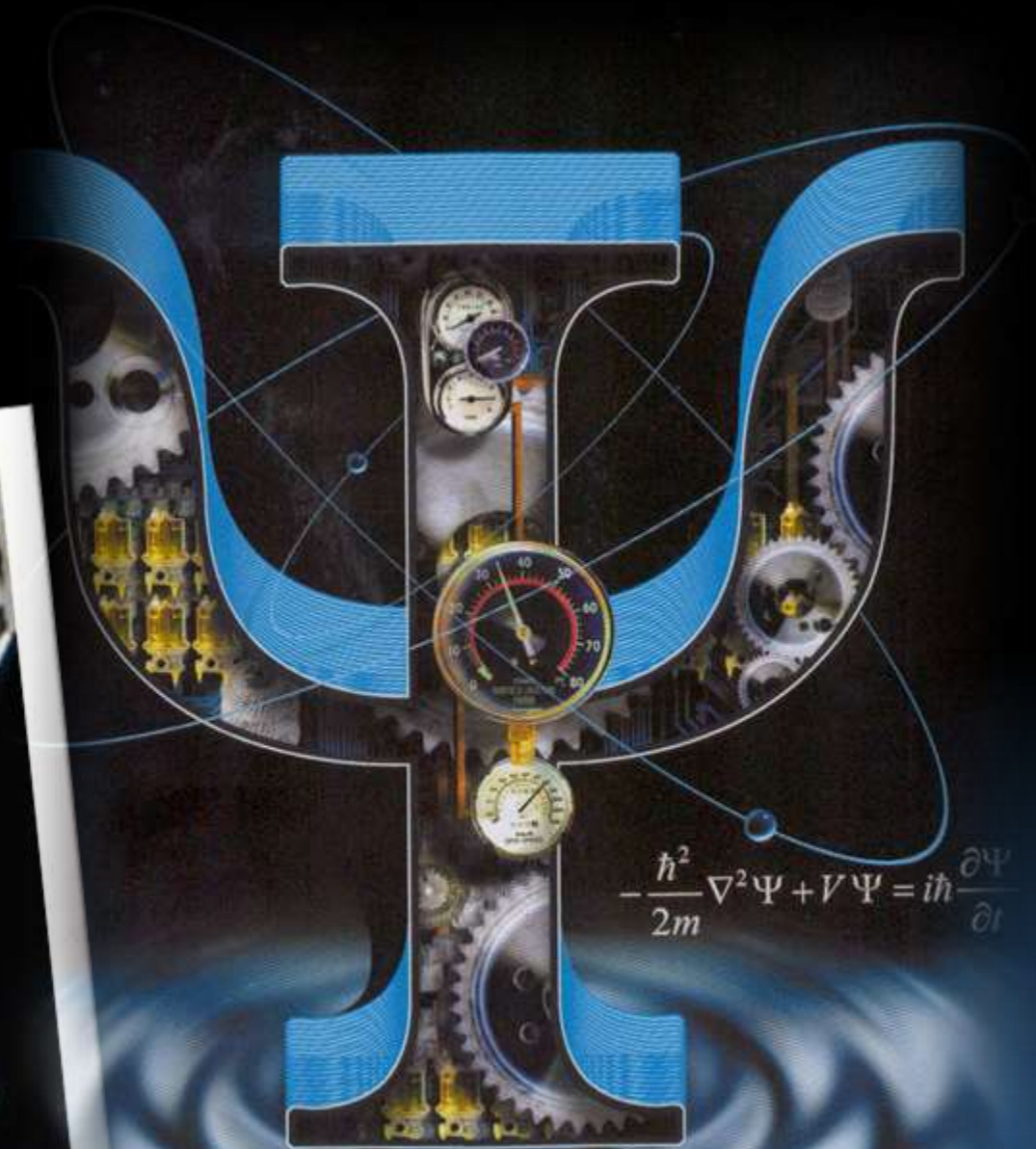
**Enredo cuántico**



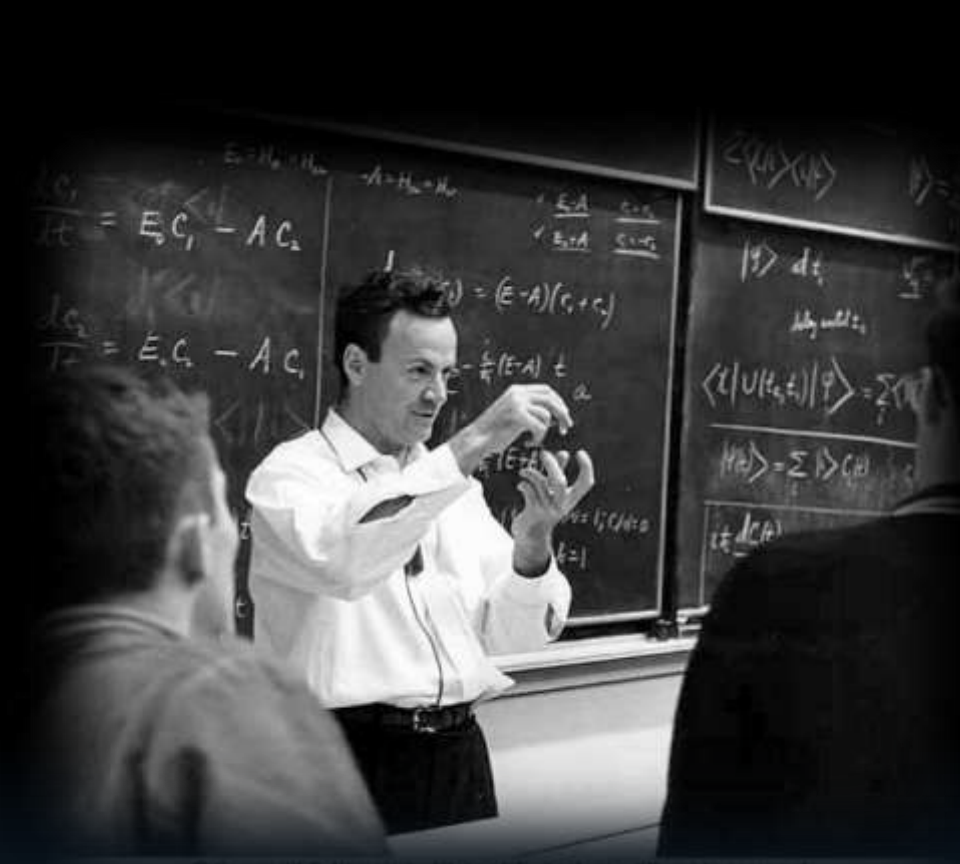
**Atom**

**Nanotechnology**

# Change of paradigma



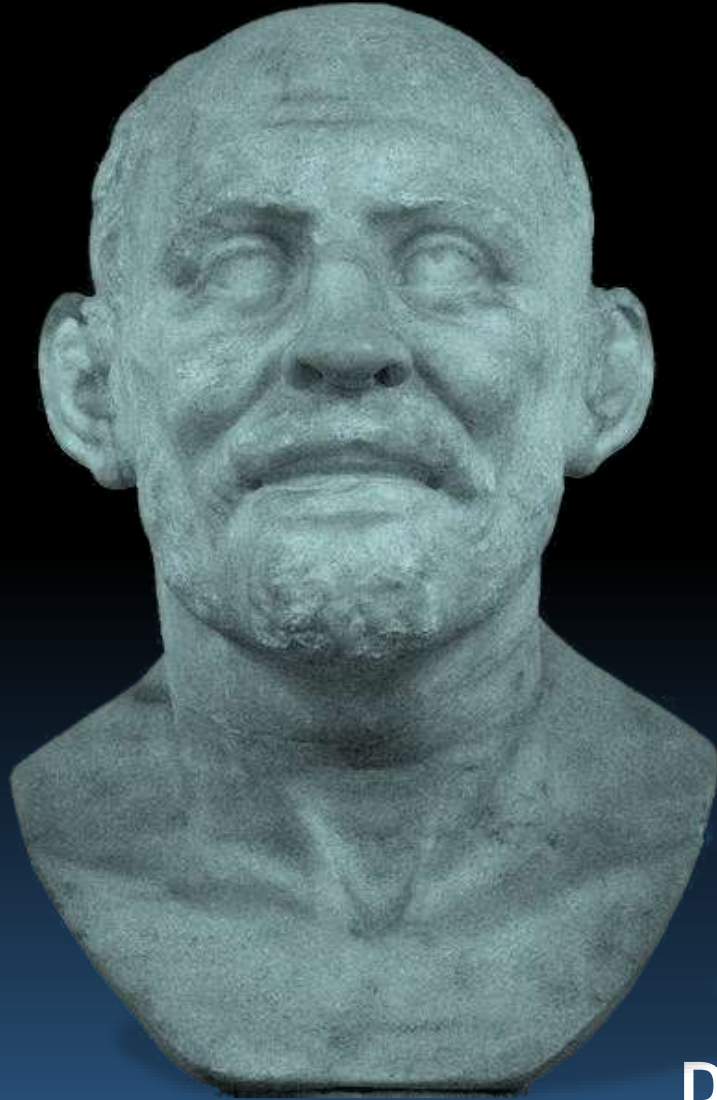
$$-\frac{\hbar^2}{2m}\nabla^2\Psi + V\Psi = i\hbar\frac{\partial\Psi}{\partial t}$$



# Richard Feynman

*Fisikako Nobel sariduna (1965)*

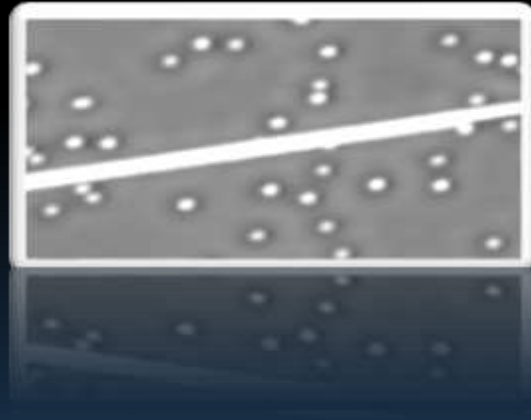
**Hipotesi atomikoa:** Zientifikoa da eragindako mundu berrunaldiei  
eragindako bigi dugaratzen diren partikula txikiak, alenduz gero elkar  
erakartzen dutenak eta hurbilduz gero elkar aldaratzen dutenak  
**Informaziorik handiena nitz gutxien erabiliz?**



**Todo está hecho de átomos**  
indestructibles, inmutables,  
cualitativamente  
indiferenciados,  
que solo difieren entre sí  
en la figura, posición u orden.

Solo la razón puede llegar  
a los átomos,  
nunca los sentidos.

**Demócrito de Abdera (460-370 aC)**



Cortesía **E. Ortega**, Lab. Nanofísica





Epicurus



Titus  
Lucretius  
Carus



De Rerum Natura

# The Elements

H 1 Hydrogen																He 2 Helium															
Li 3 Lithium	Be 4 Beryllium																B 5 Boron	C 6 Carbon	N 7 Nitrogen	O 8 Oxygen	F 9 Fluorine	Ne 10 Neon									
Na 11 Sodium	Mg 12 Magnesium																Al 13 Aluminum	Si 14 Silicon	P 15 Phosphorus	S 16 Sulfur	Cl 17 Chlorine	Ar 18 Argon									
K 19 Potassium	Ca 20 Calcium	Sc 21 Scandium	Ti 22 Titanium	V 23 Vanadium	Cr 24 Chromium	Mn 25 Manganese	Fe 26 Iron	Co 27 Cobalt	Ni 28 Nickel	Cu 29 Copper	Zn 30 Zinc	Ga 31 Gallium	Ge 32 Germanium	As 33 Arsenic	Se 34 Selenium	Br 35 Bromine	Kr 36 Krypton														
Rb 37 Rubidium	Sr 38 Strontium	Y 39 Yttrium	Zr 40 Zirconium	Nb 41 Niobium	Mo 42 Molybdenum	Tc 43 Technetium	Ru 44 Ruthenium	Rh 45 Rhodium	Pd 46 Palladium	Ag 47 Silver	Cd 48 Cadmium	In 49 Indium	Sn 50 Tin	Sb 51 Antimony	Te 52 Tellurium	I 53 Iodine	Xe 54 Xenon														
Cs 55 Cesium	Ba 56 Barium																Hf 72 Hafnium	Ta 73 Tantalum	W 74 Tungsten	Re 75 Rhenium	Os 76 Osmium	Ir 77 Iridium	Pt 78 Platinum	Au 79 Gold	Hg 80 Mercury	Tl 81 Thallium	Pb 82 Lead	Bi 83 Bismuth	Po 84 Polonium	At 85 Astatine	Rn 86 Radon
Fr 87 Francium	Ra 88 Radium																Rf 104 Rutherfordium	Db 105 Dubnium	Sg 106 Seaborgium	Bh 107 Bohrium	Hs 108 Hassium	Mt 109 Meitnerium	Ds 110 Darmstadtium	Rg 111 Roentgenium	Uub 112 Ununbium	Uut 113 Ununtrium	Uuq 114 Ununquadium	Uup 115 Ununpentium	Uuh 116 Ununhexium	Uus 117 Ununseptium	Uuo 118 Ununoctium
☛ Radioactive elements		La 57 Lanthanum	Ce 58 Cerium	Pr 59 Praseodymium	Nd 60 Neodymium	Pm 61 Promethium	Sm 62 Samarium	Eu 63 Europium	Gd 64 Gadolinium	Tb 65 Terbium	Dy 66 Dysprosium	Ho 67 Holmium	Er 68 Erbium	Tm 69 Thulium	Yb 70 Ytterbium	Lu 71 Lutetium															
		Ac 89 Actinium	Th 90 Thorium	Pa 91 Protactinium	U 92 Uranium	Np 93 Neptunium	Pu 94 Plutonium	Am 95 Americium	Cm 96 Curium	Bk 97 Berkelium	Cf 98 Californium	Es 99 Einsteinium	Fm 100 Fermium	Md 101 Mendelevium	No 102 Nobelium	Lr 103 Lawrencium															

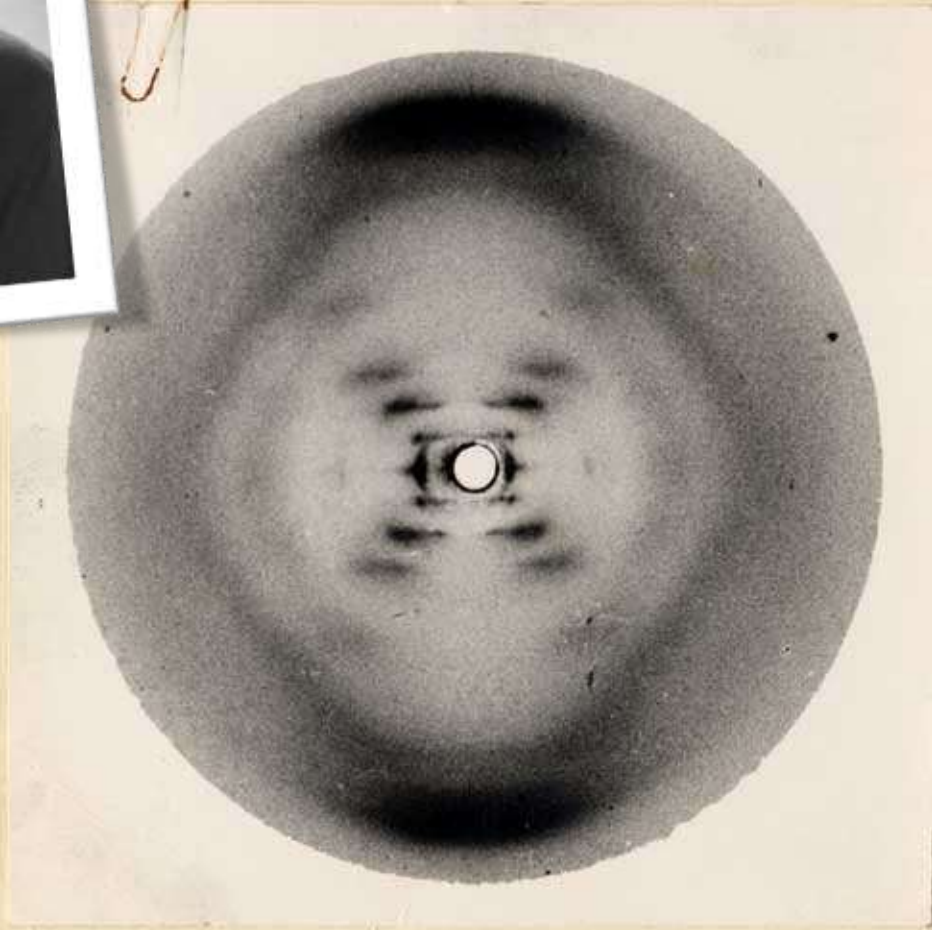
Toda la materia  
habida y por haber



**GEN**

**Biotecnología**

**Una modesta foto ...**



Franklin &  
Goshing

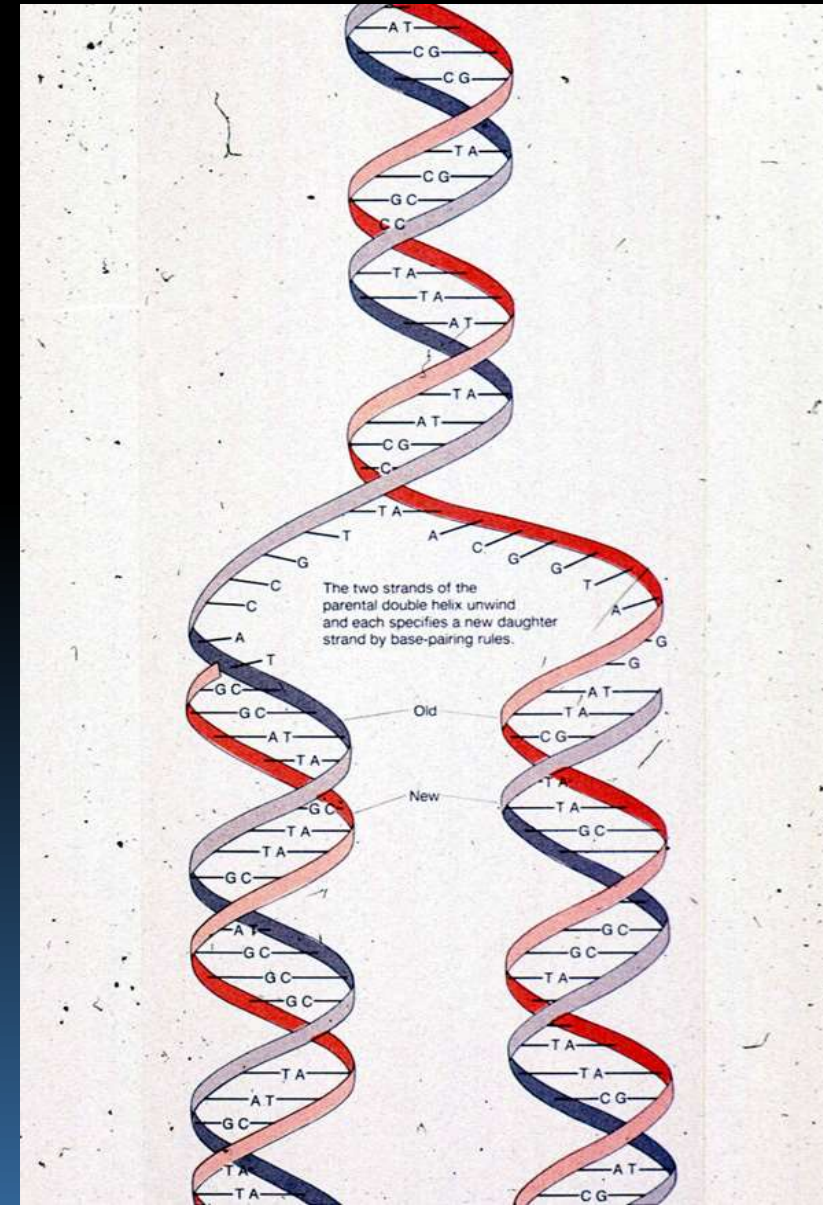
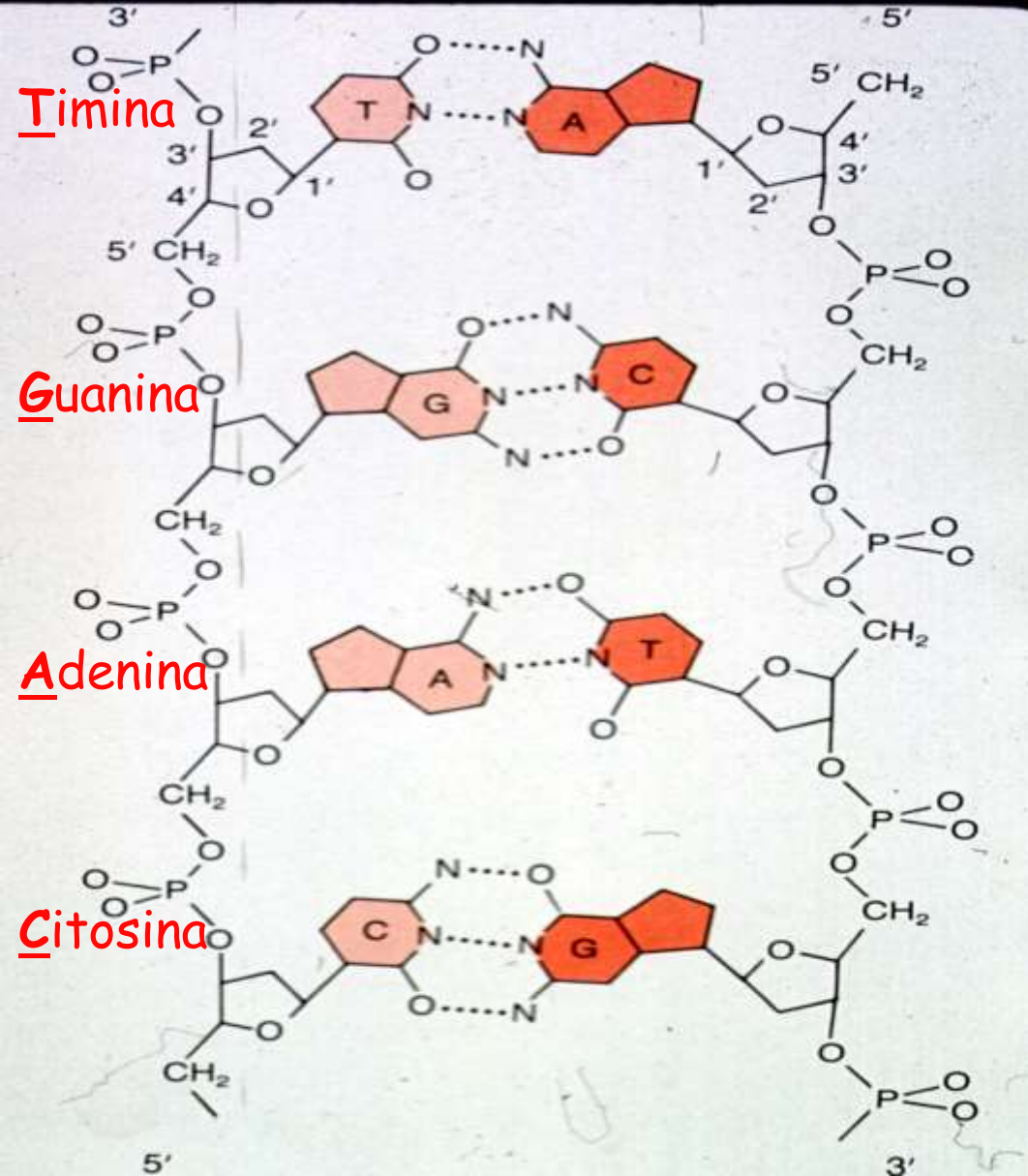
Ind. ~~Manufact~~  
Type D

Plate 1

**... da paso a  
una gran  
revolución**



# La estructura del ADN explica la naturaleza y la replicación del material genético



# La fuente de la juventud

Lucas Cranach - 1546

¿Se puede modificar genéticamente la duración de la vida humana?







**BIT**

**Información**





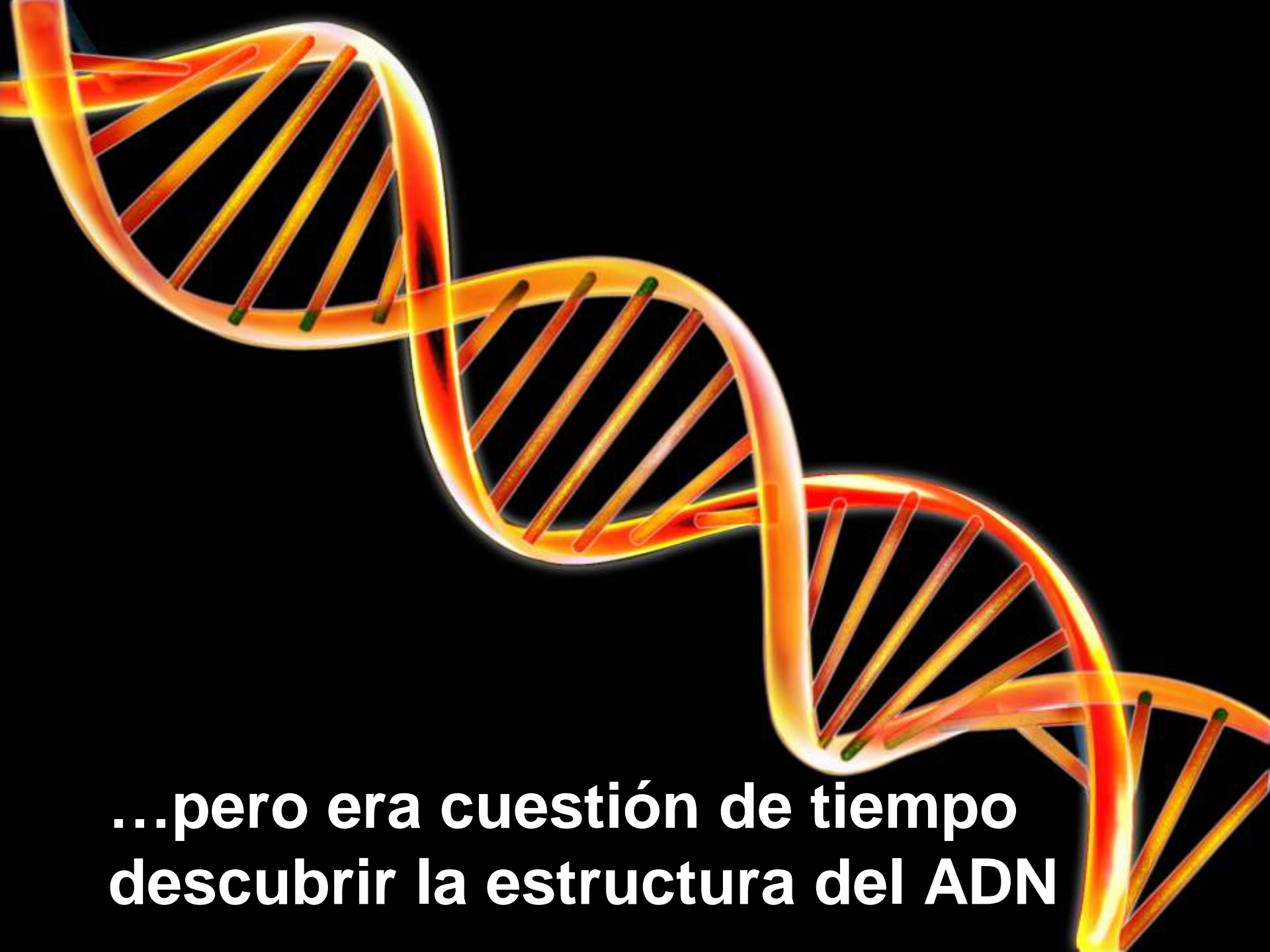
**Largo plazo**

**Colectivo**

**Progreso**



**No tendríamos la Gioconda sin  
Leonardo da Vinci...**



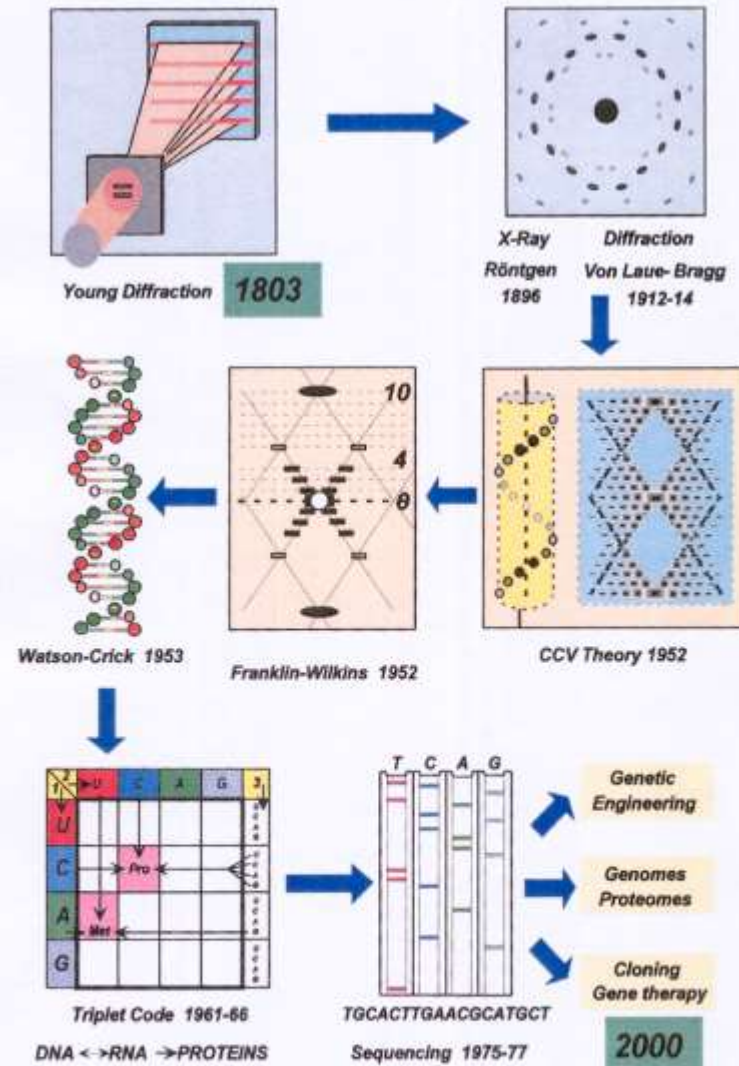
**...pero era cuestión de tiempo  
descubrir la estructura del ADN**

# an example...

## ... From what is light to what is life

*“Scribbles that change the course of human affairs”*

*Amand A. Lucas,  
Classe des Sciences –  
Académie royale de Belgique*



**FIGURE 1.** Guided tour through the history of sciences beginning with the discovery of the wave nature of light (1803) and ending with modern genetic engineering (2000). The path indicated by the arrows is described in Section 2. The central picture is a schematic representation of the real X-ray diagram in Fig. 2(a).

Todas las olas del mar deben la belleza de su perfil a las que las preceden y se retiran

*André Gide*







**LIBERTAD**

**CREATIVIDAD**

## **REPORT ATTENDANCE AT A MUSICAL CONCERT DATED**

• Much effort was absorbed in the playing of demi-quavers. This seems an excessive refinement, and it is recommended that all

In research, as in music, blind bureaucracy has the effect of the destroying imaginative creativity. If that is truly valued, it must remain free from bureaucratic excesses.

redundant passages were eliminated the concert could be reduced from 2 hours to 20 minutes.

• **Finally, it should be appreciated that if Schubert had attended to all matters he would certainly have finished his symphony.**

# **Sinfonía inacabada**

## **Franz Schubert, 1822**

More important and even more profitable than regulations and fixing targets to science is to create an **atmosphere**, an environment in which **creativity** can freely flourish.



La sublime utilidad de  
la **ciencia** inútil



**INVESTIGACIÓN FUTURA.  
NO CONCENTRARNOS SOLAMENTE  
EN LO APLICADO**

## The Many Virtues of Basic Science: I. Clinical Medicine

- 1894 X-Rays
- 1932 Antimatter
- 1950 Nuclear Magnetism
- 1912 Radioactive Isotopes
- 1934 Cyclotron
- 1957 Lasers
- 1986 Polymerase Chn Rctn
- 1928 Penicillin (by chance!)
- 1953 DNA Structure
- CAT Scanners
- PET Scanners
- MRI Scanners
- Brachytherapy
- Particle Beam Therapy
- Microsurgery
- Forensic Medicine
- Disease Control
- Gene Therapy

**Each of these discoveries earned a Nobel Prize!**

## II. Basic Science and Information Technology

- 1888 Radio Waves
- 1947 Holography
- 1947 Transistors
- 1951 Integrated Circuits
- 1966 Optical Fibers
- 1976 PK Cryptography
- 1988 Giant Magnetoresistance
- 1986 High T Superconductors
- 2012 Quantum Manipulation
- Wireless Transmission
- Secure Credit Cards
- 1st Computer Revolution
- 2nd Computer Revolution
- Rapid Data Transmission
- Secure Data Transmission
- Disk Readout
- Energy Storage (?)
- Quantum Computers (?)

**All but two of these discoveries earned Nobel Prizes!**

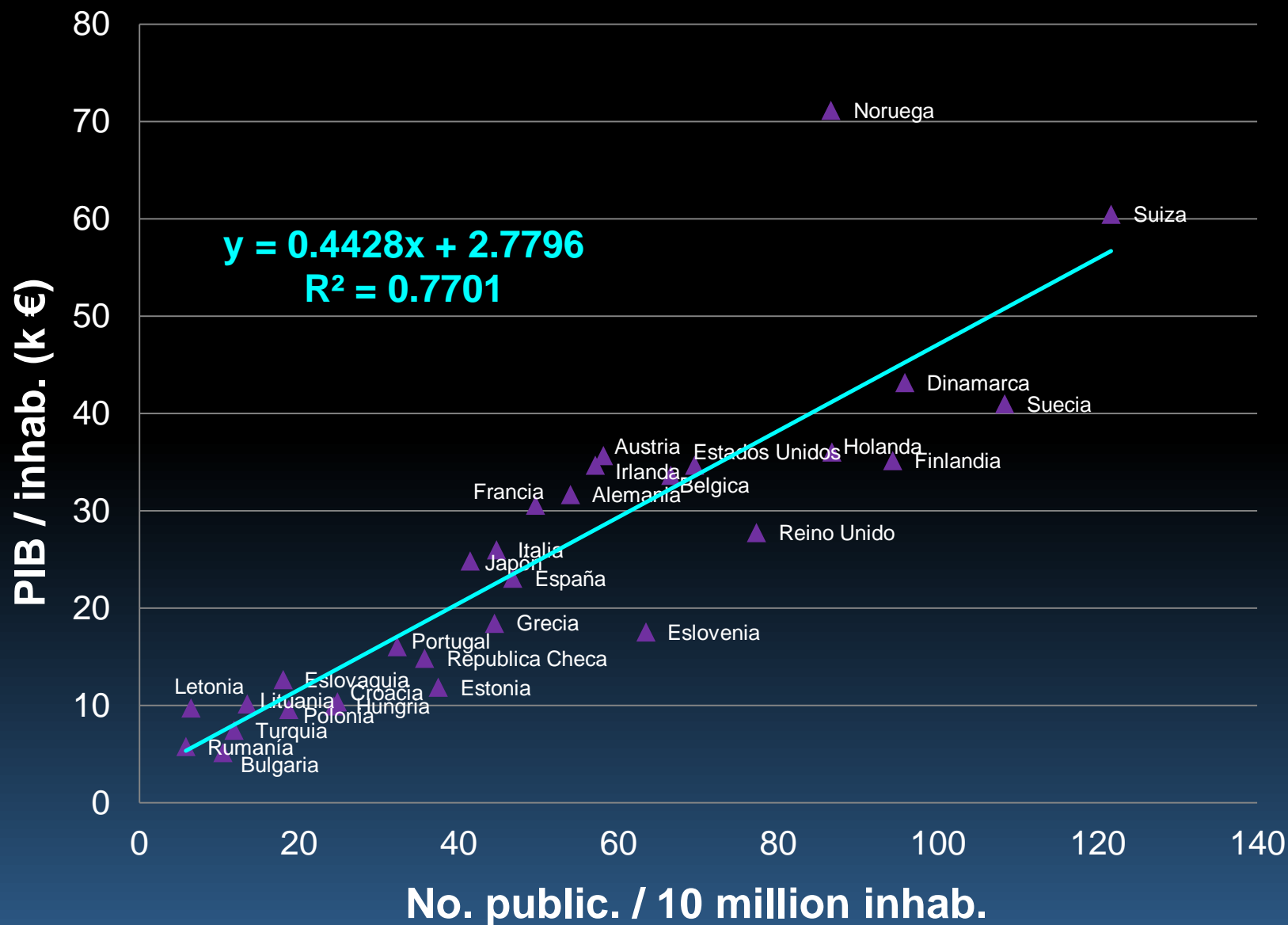
LA RIQUEZA DE LAS **NACIONES**

se deberá cada vez más a

LA RIQUEZA DE LAS **NOCIONES**



# Wealth (PIB) vs number of Publications 2011



**“Regard science and technology as our primary productive force, talent as our primary resource, and innovation as our primary driver of growth”**

**Xi Jinping**

Nature, 2022



**We are not at the end of  
science, but at the  
beginning...**

**The law of conservation  
of ignorance**

MISTERIO

MISTERIO

MISTERIO

MISTERIO

MISTERIO

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MISTERIO

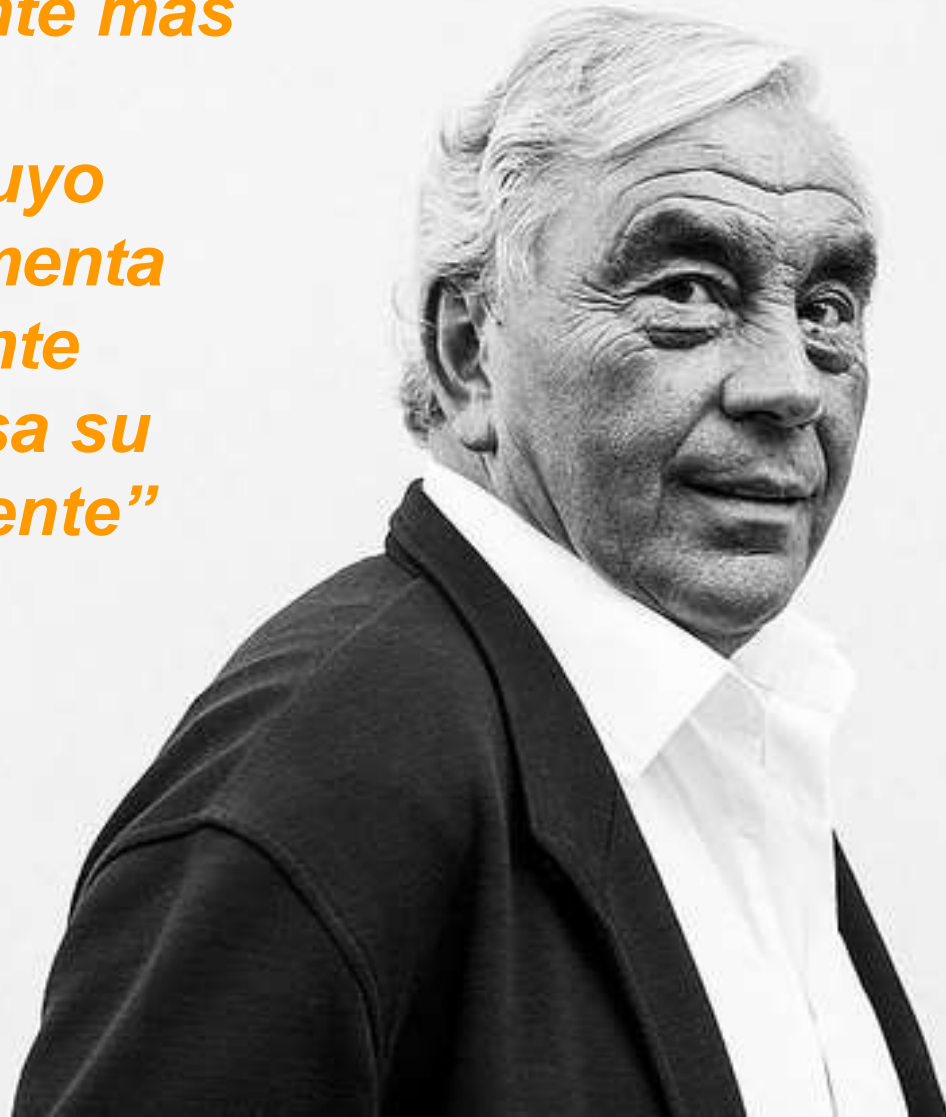
MISTERIO

MISTERIO

MISTERIO

La expansión de las fronteras del  
conocimiento nos pone en contacto con lo  
desconocido\*

***“La naturaleza es el documento intelectualmente más fecundo y gratificante, cuyo contenido aumenta inagotablemente según progresa su lectura inteligente”***





M. Faraday

“La gran belleza de nuestra ciencia es que su avance, lejos de agotar el campo de investigación, en algún grado abre las puertas a un conocimiento más vasto y diverso, desbordante de hermosura y utilidad”

**NECESIDAD DE UNA CULTURA CIENTÍFICA**

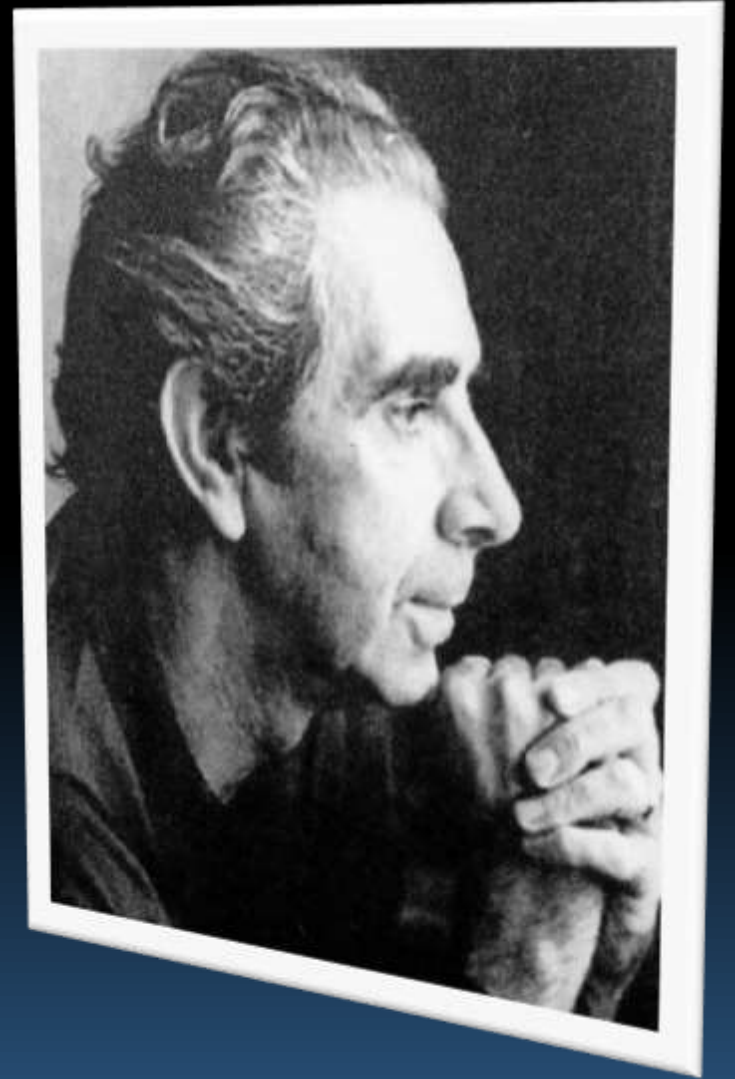
“So, as long as science is humble enough,  
and open enough, and transparent  
enough to accept the self-correction it is a  
beautiful process.”

**Dr. Fauci**



## Koldo Mitxelena

*“Ez naizela honera  
agertu neure etxerako  
edo neure etxearen  
alde mintzatzeko  
asmotan. Geure  
etxearen alde, guztion  
etxearen alde mintzatu  
nahiko nuke”*




A black and white portrait of T. S. Eliot, showing him from the chest up. He is wearing a suit and tie, and has his right hand resting against his face in a thoughtful pose. The portrait is tilted slightly to the right and is set against a dark background.

“Where is the **wisdom**  
we have lost in **knowledge**?”

Where is the **knowledge**  
we have lost in **information**?”

**T. S. Eliot**

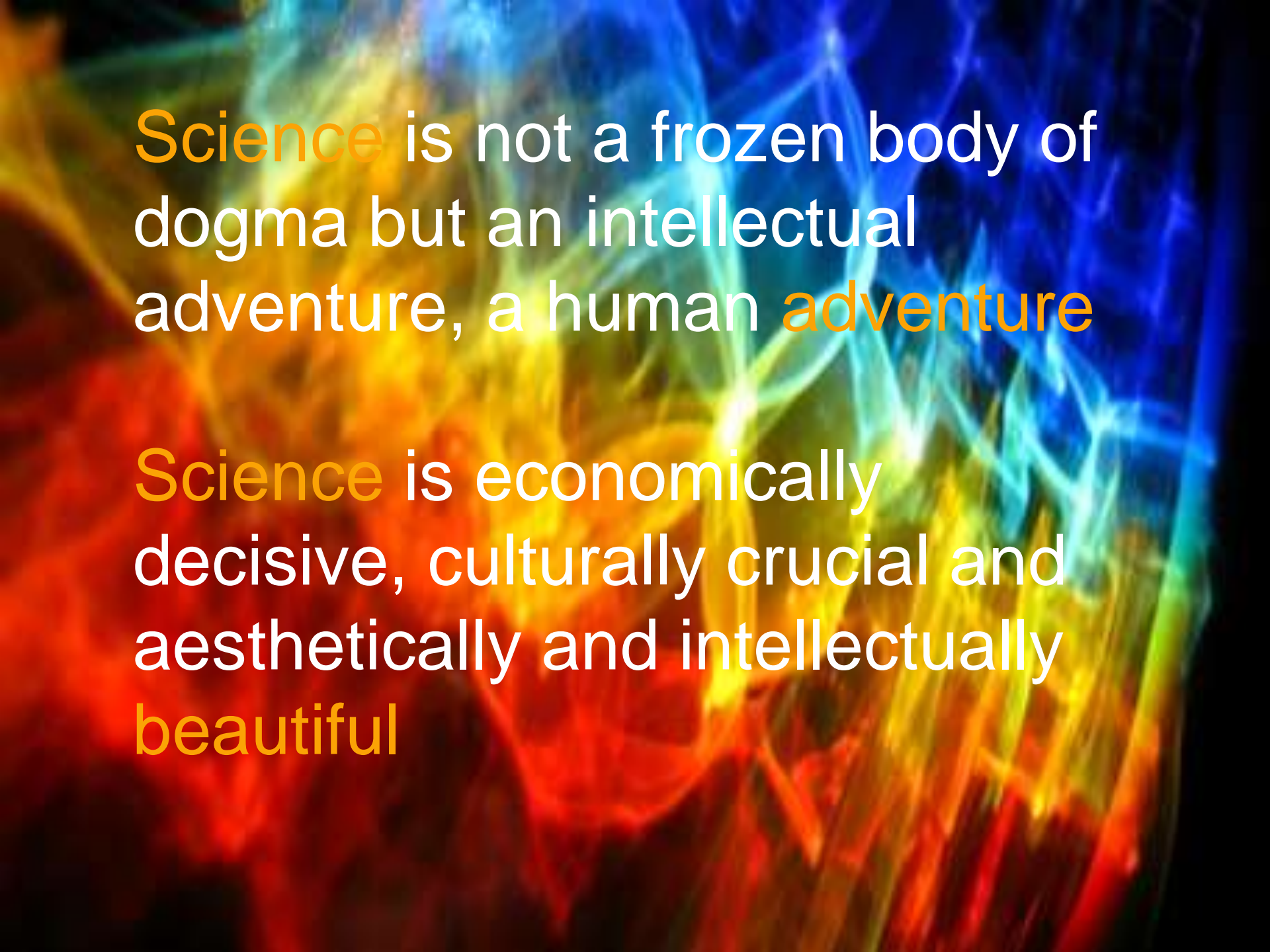
“Choruses from the Rock”

A pair of hands is shown holding a small, realistic-looking globe of the Earth. The hands are positioned at the bottom and sides of the globe, with fingers gently gripping it. The globe shows the continents of North and South America in green and yellow, surrounded by blue oceans and white clouds. The background is dark, making the hands and the globe stand out.

The big challenges of mankind,  
energy, health, food, water, balance with the  
natural environment, inequality and increase of  
intolerance and fundamentalism ... will not be  
solved with less science and less education, but  
with more Science and more Education.

“He, that will not apply new  
remedies, must accept new evils,  
for time is the greatest innovator”

F. Bacon



Science is not a frozen body of dogma but an intellectual adventure, a human **adventure**

Science is economically decisive, culturally crucial and aesthetically and intellectually **beautiful**



**Mila esker!**

**Science was a  
passing phase of  
human culture and is  
now fortunately  
over”**



**George Steiner**, Conference entitled “Is science nearing its  
limits?”