



# Universidad Nacional de Río Negro

## Int Partículas, Astrofísica & Cosmología - 2021

- **Unidad**      02-Astrofísica, estrellas y planetas
- **Clase**        UO2 C06 - 10/16
- **Fecha**        06 Oct 2021
- **Cont**          Vida
- **Cátedra**      Asorey



# Contenidos: un viaje en el tiempo y el espacio

## HOW DID OUR UNIVERSE BEGIN?

Some 13.8 billion years ago our entire visible universe was contained in an unimaginably hot, dense point, a billionth the size of a nuclear particle. Since then it has expanded—a lot—fighting gravity all the way.

**Inflation**  
In less than a nanosecond a massive energy field inflates space 10<sup>26</sup> times, stretching it with a soup of subatomic particles called quarks.

**Age:** 10<sup>-2</sup> milliseconds  
**Size:** Infinitesimal to golf ball

**Early building blocks**  
The universe expands, cools. Quarks clump into protons and neutrons; then strings of atoms begin to form. Perhaps dark matter forms.

**Age:** .01 milliseconds  
**Size:** 1-billionth present size

**First nuclei**  
As the universe continues to cool, the lightest nuclei of hydrogen will form. A thick fog of particles blocks all light.

**Age:** .01 to 200 seconds  
**Size:** .0009 present size

**First atoms, first light**  
As electrons begin orbiting nuclei, creating atoms, the glow from their inflection points is unveiled. This light is as far back as our instruments can see.

**Age:** 380,000 years  
**Size:** .0009 present size

**The “dark ages”**  
For 300 million years this cosmic fog of radiation is the only light. Clumps of matter that will become galaxies glow brightest.

**Age:** 380,000 to 300 million years  
**Size:** .0009 to 0.1 present size

**Gravity wins: first stars**  
Dense gas clouds collapse under their own gravity and of dark matter to eventually form galaxies and stars. Nuclei fusion lights up the stars.

**Age:** 300 million years  
**Size:** 0.1 present size

**Antigravity wins**  
After being slowed for billions of years, gravity gives way to antigravity, cosmic expansion accelerates again. The culprit: dark energy. Its nature: unclear.

**Age:** 10 billion years  
**Size:** .77 present size

**Today**  
The universe continues to expand, becoming ever less dense. As a result, fewer new stars and galaxies are forming.

**Age:** 13.8 billion years  
**Size:** Present size

## COSMIC QUESTIONS

In the 20th century the universe became a story—a scientific one. It had always been seen as static and eternal. Then astronomers observed other galaxies flying away from ours, and Einstein's general relativity theory implied space itself was expanding—which meant the universe had once been denser. What had seemed eternal now had a beginning and an end. But what beginning? What end? Those questions are still open.

## WHAT IS OUR UNIVERSE MADE OF?

Stars, dust and gas—the stuff we can discern—make up less than 5 percent of the universe. Their gravity can't account for how galaxies hold together. Scientists figure about 24 percent of the universe is a mysterious dark matter—perhaps exotic particles formed right after inflation. The rest is dark energy, an unknown energy field or property of space that counters gravity, providing an explanation for observations that the expansion of space is accelerating.



## WHAT IS THE SHAPE OF OUR UNIVERSE?

Einstein discovered that a star's gravity curves space around it. But is the whole universe curved? Might space close up on itself like a sphere or curve the other way, opening out like a saddle? By studying cosmic background radiation, scientists have found that the universe is poised between the two: just dense enough with just enough gravity to be almost perfectly flat, at least the part we can see. What lies beyond we can't know.

**Observable Universe**  
The universe began 13.8 billion years ago. Because it has been expanding ever since, the farthest observable edge is now 47 billion light-years.

**The Unknown Beyond**  
What we can't see. The possible shapes are:



## Unidad 2 Astrofísica, escalas medias

### DO WE LIVE IN A MULTIVERSE?

What came before the big bang? Maybe other big bangs. The uncertainty principle holds that even the vacuum of space has density fluctuations. Inflation theory says our universe exploded from such a fluctuation—a random event that, odds are, had happened many times before. Our cosmos may be one in a sea of others just like ours—or nothing like ours. These other cosmos will very likely remain forever inaccessible to observation, their possibilities limited only by our imagination.

## HOW WILL IT END?

Which will win in the end, gravity or antigravity? Is the density of matter enough for gravity to halt or even reverse cosmic expansion, leading to a big crunch? It seems unlikely—especially given the power of dark energy, a kind of antigravity. Perhaps the acceleration in expansion caused by dark energy will trigger a big rip that shreds everything, from galaxies to atoms. If not, the universe may expand for hundreds of billions of years, long after all stars have died.



## Unidad 1 Partículas, lo más pequeño



By through the universe on  
our digital edition  
LONDON PHOTOS: ANDREW TAYLOR; GENEVA: PHILIPPE DESMAZES; ART: MONTAGNA DESIGN;  
SOURCES: CHARLES BENNETT, JOHN HESTER, ROBERT KAPPAUF, CHRISTOPHER LUDWIG, UNIVERSITY OF CHICAGO; COURTESY, 2012 NATIONAL GEOGRAPHIC SOCIETY

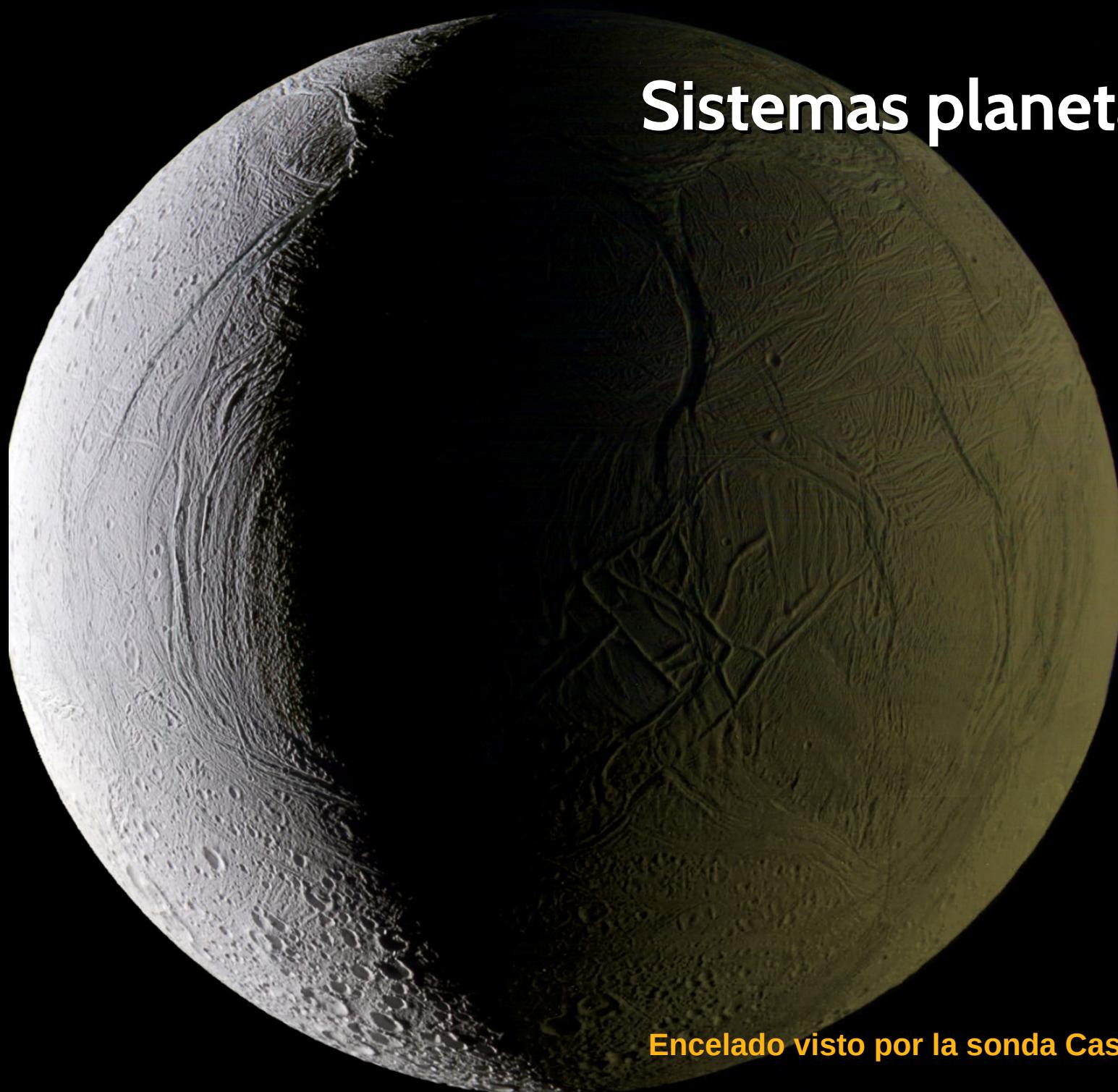


# U2: Astrofísica, escalas intermedias

## 5 encuentros, del 01/Sep al 29/Sep

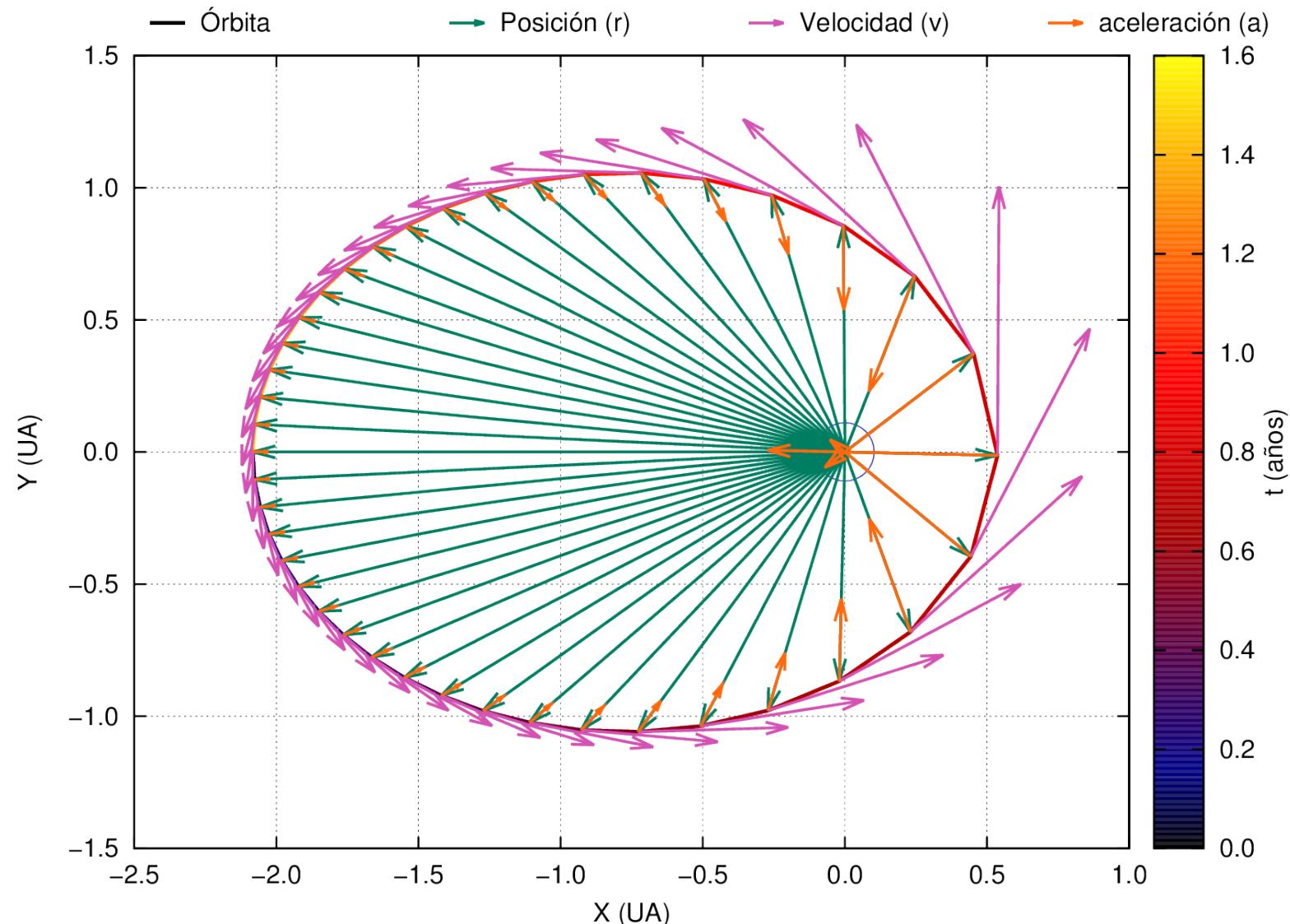
- **Estrellas.**
  - **Modelo politrópico. La fusión nuclear estelar.**
  - **Clasificación estelar. Diagrama H-R.**
  - **Evolución estelar. Nebulosas.**
- **Planetas**
  - **El Sistema Solar**
  - **Exoplanetas**
  - **Vida en el Universo: Astrobiología.**
- **Trabajo unidad → fecha máxima de entrega 12/Nov**

# Sistemas planetarios



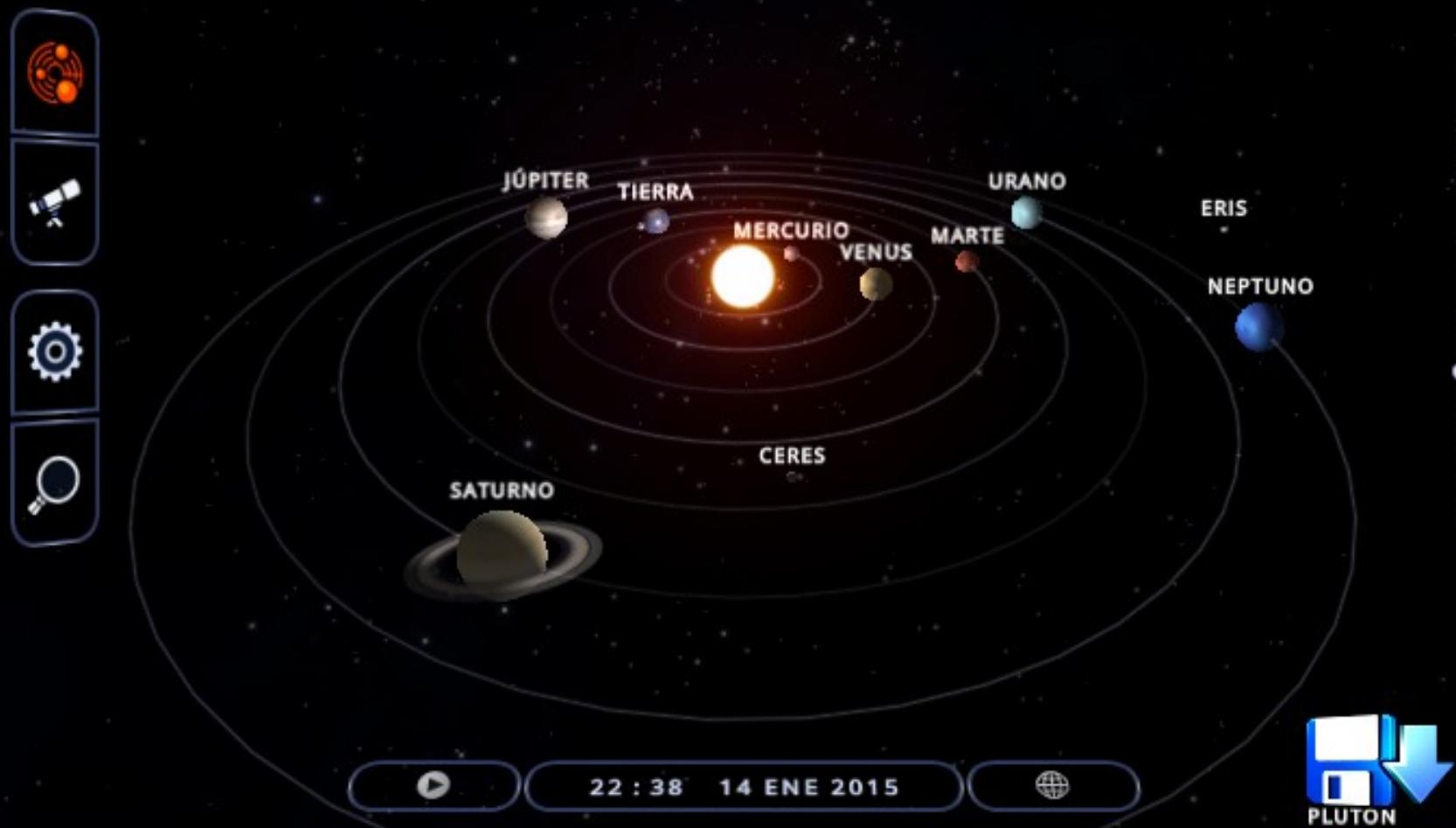
Encelado visto por la sonda Casini

# Órbita+posición+velocidad+aceleración

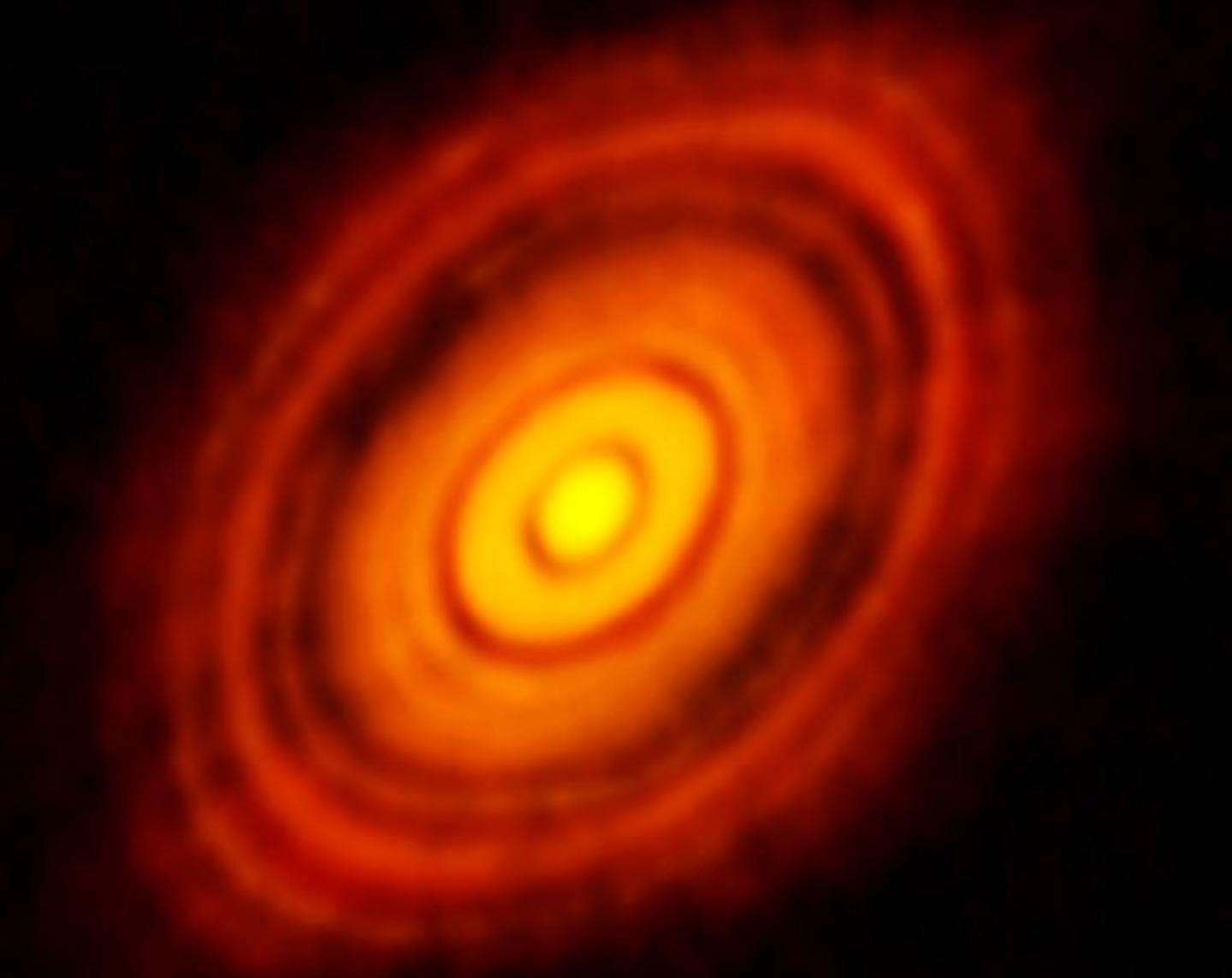


# “Solar System Scope”

<https://www.solarsystemscope.com/>



# HL Tauri ( $t_s \sim 10^5$ años) observado por ALMA

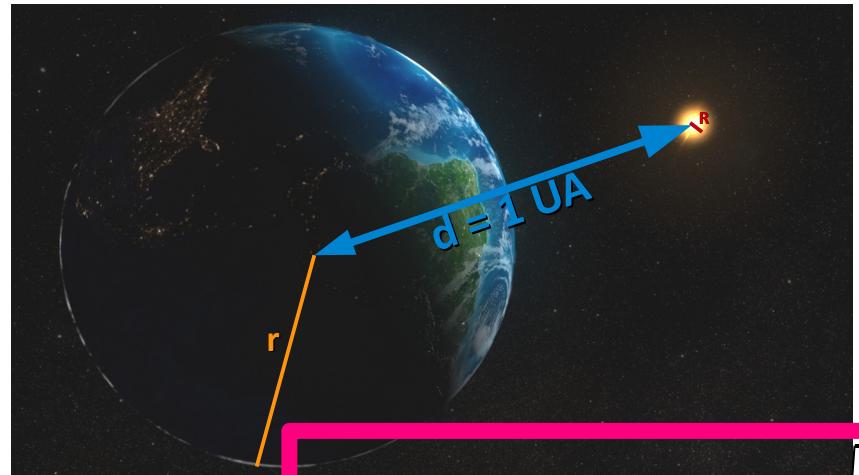


# Temperatura orbital

$$T_p = \sqrt[4]{\frac{L_s}{16\pi\sigma d^2}}$$

$$d = \sqrt{\frac{L_s}{16\pi\sigma T_p^4}} \rightarrow d_{T_p} \propto \sqrt{L_s}$$

$$\left( \frac{d_{T_p}}{1\text{UA}} \right) = \left( \sqrt{\frac{L_\odot}{16\pi\sigma T_p^4 (1\text{UA})^2}} \right) \sqrt{\frac{L_s}{L_\odot}}$$



$$d_{273K} = 1,0394 \sqrt{\frac{L_s}{L_\odot}}$$

$$d_{373K} = 0,5568 \sqrt{\frac{L_s}{L_\odot}}$$

**¡CUIDADO!** Esto depende de la presión atmosférica y de la composición de la atmósfera (gases de efecto invernadero)

<https://exoplanets.nasa.gov/>

The screenshot shows the homepage of the NASA Exoplanet Exploration website. The header features the NASA logo and the text "EXOPLANET EXPLORATION Planets Beyond Our Solar System". To the right are links for "What is an Exoplanet?", "Explore", "News", "Multimedia", "More", and "For Scientists", along with a search icon. The main visual is a large, detailed illustration of a green, rocky exoplanet against a dark, star-filled background. Below the image, the text "Search for New Worlds at Home With NASA's Planet Patrol Project" is displayed, followed by a dropdown menu. At the bottom, there is a summary of current findings: "Exoplanets 4,284 CONFIRMED", "NASA CANDIDATES 5,573", "PLANETARY SYSTEMS 3,179", and links to "Glossary" and "FAQ". A "click to expand" button is located above the summary statistics.

NASA EXOPLANET EXPLORATION  
Planets Beyond Our Solar System

What is an Exoplanet? Explore News Multimedia More For Scientists

Search for New Worlds at Home With NASA's Planet Patrol Project

Exoplanets 4,284 CONFIRMED

NASA CANDIDATES 5,573

PLANETARY SYSTEMS 3,179

click to expand

Last update: October 4, 2020

Glossary ›  
FAQ ›

<https://exoplanets.nasa.gov/eyes-on-exoplanets>

The screenshot shows a 3D visualization of the Milky Way Galaxy. The Sun is located at the center of the visible disk of stars. A bright yellow and white starburst surrounds the Sun, representing the galactic plane. Numerous smaller stars of various colors (yellow, orange, white) are scattered throughout the dark background, representing other stars and stellar systems. In the bottom left corner, there is a text overlay: "Milky Way Galaxy" with a small icon, "3,179 solar systems | 4,284 confirmed planets". On the left side, a message says "You are 8,774 light-years from Earth". The top navigation bar includes the NASA logo, the title "EYES ON EXOPLANETS beta", and links for "HOME", "BROWSE PLANETS", "MISSIONS", and a search icon. A "FILTER" button is located in the bottom right corner, with options for "Planet Type", "Missions", and "Observatory". The status "Current filter: All Planet Types" is displayed below the filter button.

<https://exoplanets.nasa.gov/keplerscience/>

# Kepler

BY THE NUMBERS



**9.6** YEARS IN SPACE



**2** MISSIONS COMPLETED

**3.12** GALLONS FUEL USED



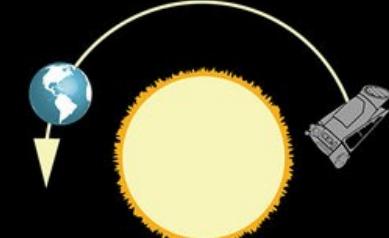
[www.nasa.gov/kepler](http://www.nasa.gov/kepler)



**61** SUPERNOVAE DOCUMENTED

FROM EARLIEST STAGES OF EXPLOSION

**94** MILLION MILES AWAY



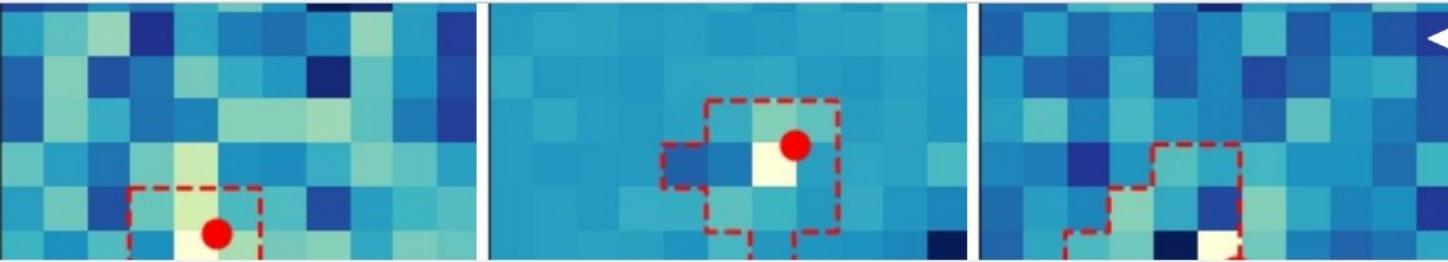
@NASAKepler



As of October 24, 2018

# Planet Patrol → ciencia ciudadana

<https://www.zooniverse.org/projects/marckuchner/planet-patrol>



19 people are talking about **Planet Patrol** right now.

[Join in](#)

PLANET PATROL STATISTICS

100% Complete

3,287 Volunteers	350,902 Classifications	20,318 Subjects	20,318 Completed Subjects
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**WORDS FROM THE RESEARCHER**

 *"With your help, we can find those small planets, long-period planets, planets around unusual host stars, and other rare systems that defeat automated search"*

**ABOUT PLANET PATROL**

NASA's Transiting Exoplanet Survey Satellite (TESS) mission will take pictures of more than a million stars to search for planets orbiting them, called "transiting exoplanets". We expect this mission will see thousands of these transiting exoplanets when they pass in front of nearby stars and periodically block some of the starlight.

But sometimes when a star dims like that, it's not because of a planet. Variable stars, eclipsing binary stars, blended stars, glitches in the data, etc. can cause a similar effect. We need

**EXTERNAL PROJECT LINKS**

- [ExoFOP-TESS](#)
- [NASA TESS](#)
- [MAST TESS](#)
- [Simbad](#)
- [NASA SOLVE](#)



# Pero si hay otros planetas, ¿hay vida?

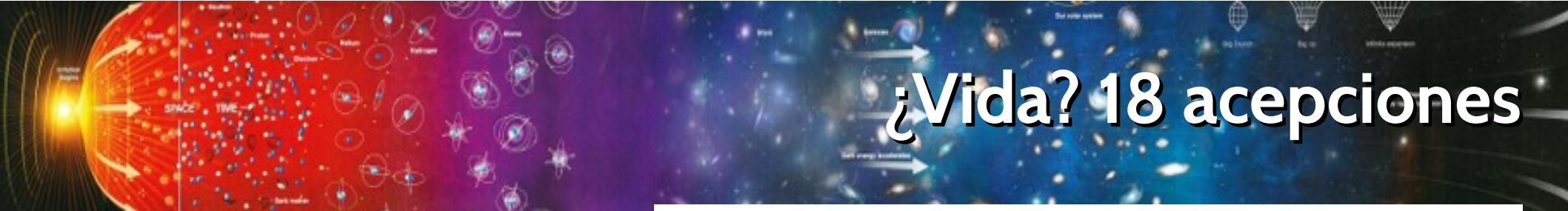


- Astrobiología.

## astrobiología

De *astro-* y *biología*.

1. f. Rama interdisciplinar de la ciencia cuyo objetivo es el origen, evolución y distribución de vida en el universo fuera de la Tierra.



# ¿Vida? 18 acepciones

- Gracias rae: tantas palabras y tan poco contenido... ;-)

## vida

Del lat. *vita*.

1. f. Fuerza o actividad esencial mediante la que obra el ser que la posee.
2. f. Energía de los seres orgánicos.
3. f. Hecho de estar vivo. *Le debe la vida a un medicamento.*
4. f. Existencia de seres vivos en un lugar. *No es posible la vida en Marte.*
5. f. Ser vivo. *Hizo nacer la vida en este jardín.*
6. f. Manera de vivir. *Su hija les cambió la vida.*
7. f. Estado o condición a que está sujeta la manera de vivir de una persona. *Vida monacal, de soldado.*
8. f. Actividad que desarrolla una persona o una comunidad. *Vida política, social, sexual.*
9. f. Tiempo que transcurre desde el nacimiento de un ser hasta su muerte o hasta el presente. *Una larga vida.*
10. f. Duración de una cosa. *Un electrodoméstico de vida corta.*
11. f. Narración de los hechos principales de la **vida** de una persona. *Lee vidas de santos.*
12. f. Animación, vitalidad de una persona o de una cosa. *Esta ciudad tiene poca vida nocturna. Es un cuadro con mucha vida.*
13. f. Viveza o ardor, especialmente de los ojos.
14. f. Cosa que origina suma complacencia. *Esta brisa es la vida.*
15. f. Cosa que contribuye o sirve al ser o conservación de otra. *El agua es vida.*
16. f. Conjunto de los bienes necesarios para vivir. *La vida en esta ciudad es muy cara.*
17. f. Existencia después de la muerte.
18. f. Rel. Visión y gozo de Dios en el cielo. *Mejor vida. Vida eterna.*



# ¿qué es la vida?



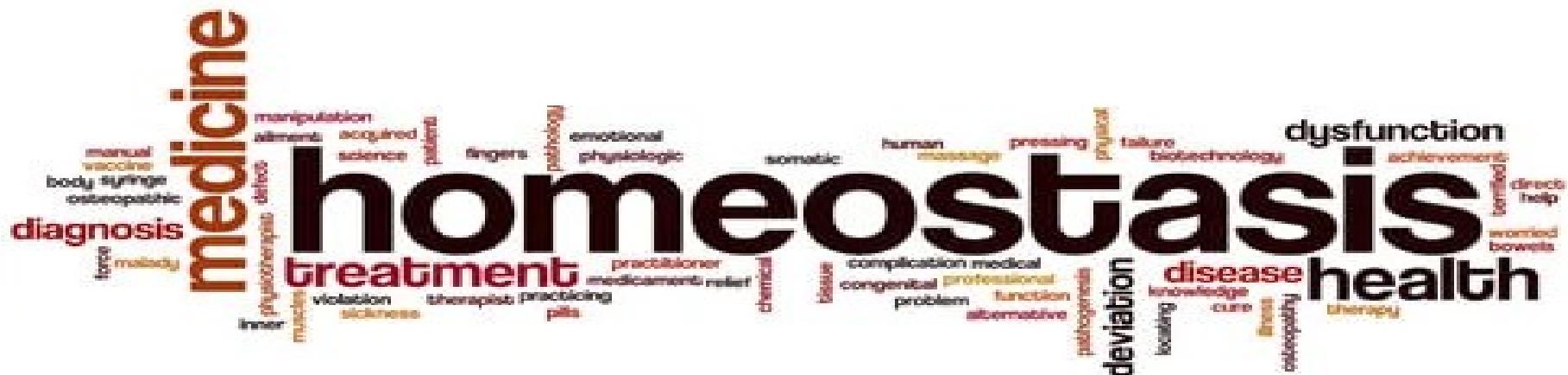
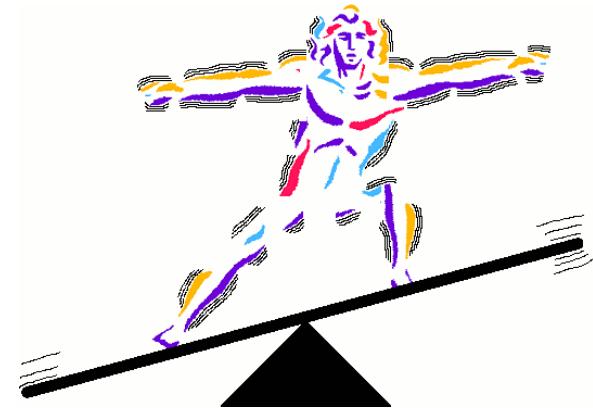
# Vida, por Wikipedia

<https://es.wikipedia.org/wiki/Vida>

- “puede definirse como la capacidad de administrar los recursos internos de un ser físico de forma adaptada a los cambios producidos en su medio, sin que exista una correspondencia directa de causa y efecto entre el ser que administra los recursos y el cambio introducido en el medio por ese ser, sino una asymptota de aproximación al ideal establecido por dicho ser, ideal que nunca llega a su consecución completa por la dinámica del medio”

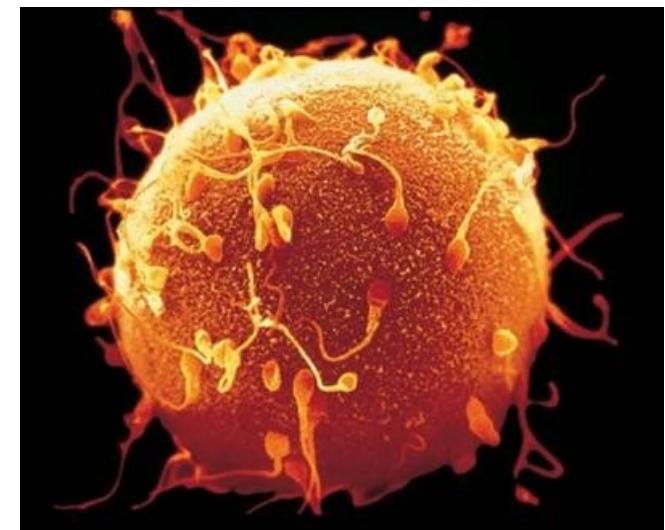
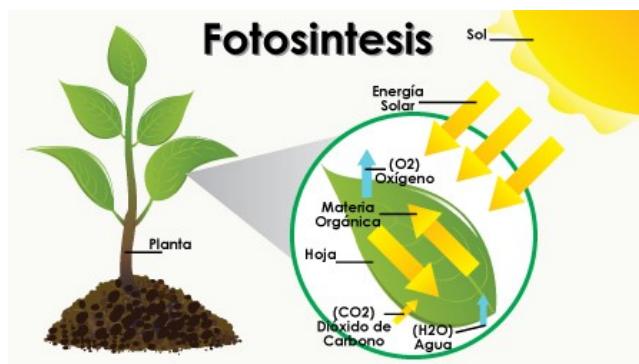
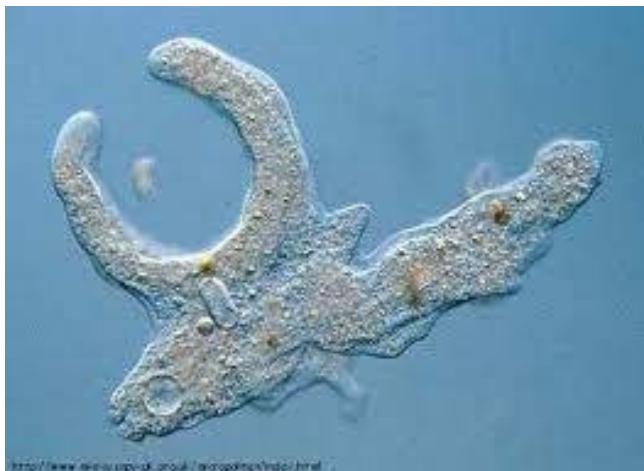
# Homeostasis → Condición de equilibrio

- **Homeostasis**: estado de equilibrio físico y químico estable alcanzado y mantenido por los sistemas vivos
    - Autoregulación → Mecanismos regulatorios
      - receptores, centros de control, efectores
      - retroalimentación
    - En equilibrio → resistencia natural al cambio
    - Fuera de equilibrio → adaptación → nuevos equilibrios



# Tres funciones básicas de un ente vivo

- Relación: con otros entes: simbiosis, parasitismo, cooperación, ...
- Nutrición: intercambio con el medio
- Reproducción: creación de nuevos entes similares al original





# Para la biología, si está vivo tiene que...

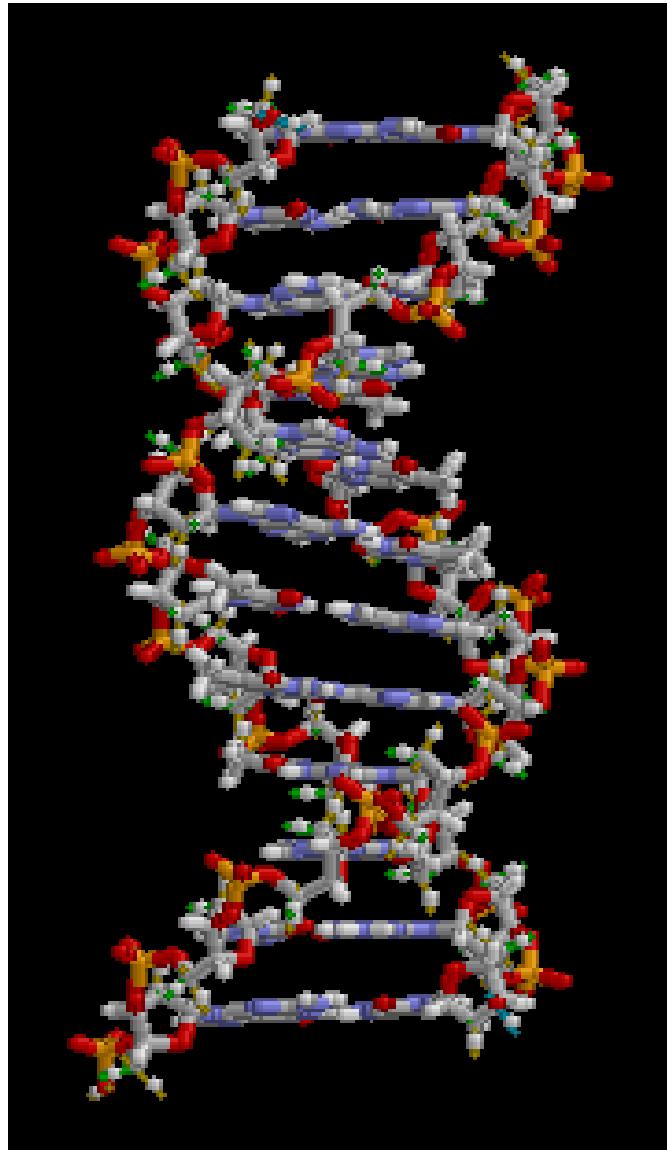
- (auto)organización
- crecimiento
- reproducción
- evolución
- homeostasis
- Movimiento
- Si falta algo de esto → no está vivo (**virus, viroides, células cancerosas**)



# Qué es la Vida? E. Schrödinger

- La vida no viola las leyes de la termodinámica, aumentan su complejidad a costa de aumentar la entropía general en los procesos que hacen parte de esta
  - → “*Los sistemas vivos son una organización especial y localizada de la materia, donde se produce un continuo incremento de orden sin intervención externa*”. (wikipedia → Vida → Termodinámica)
- La química de la herencia debe basarse en secuencias aperiódicas con la necesidad de una secuencia informativa que debe ser transmitida
  - → “*todo organismo vivo contiene información hereditaria reproducible codificada en los ácidos nucleicos los cuales controlan el metabolismo celular a través de unas moléculas (proteínas) llamadas enzimas que catalizan o inhiben las diferentes reacciones biológicas.*” (wikipedia→Vida→Bioquímica)

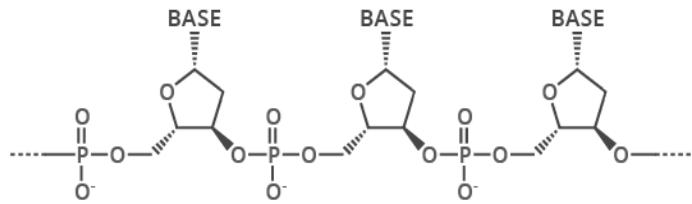
# Una molécula que transporte información



- 4 pares de bases:
  - Adenina - Timina (A-T)
  - Citosina - Guanina (C-G)
  - Anibal Troilo y Carlos Gardel
- Código genético
  - 3 pares de bases → codón
  - 1 codón → 1 aminoácido
  - El código no es único
  - Codones de inicio y terminación

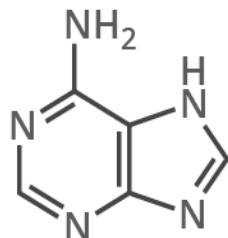
# THE CHEMICAL STRUCTURE OF DNA

# THE SUGAR PHOSPHATE 'BACKBONE'

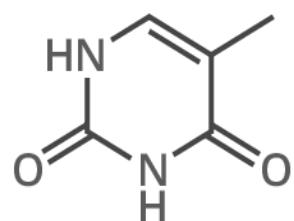


DNA is a polymer made up of units called nucleotides. The nucleotides are made of three different components: a sugar group, a phosphate group, and a base. There are four different bases: adenine, thymine, guanine and cytosine.

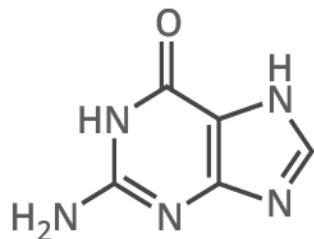
# A ADENINE



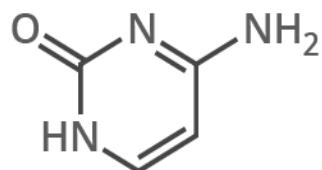
**T** THYMINE



# G GUANINE

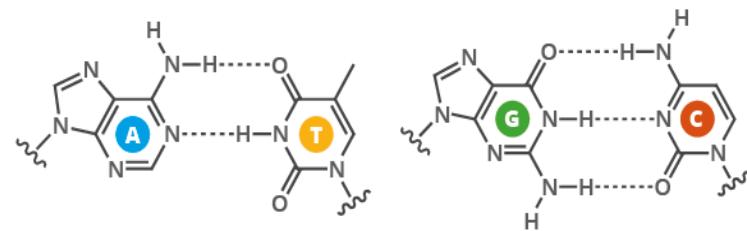


# C CYTOSINE



# WHAT HOLDS DNA STRANDS TOGETHER?

DNA strands are held together by hydrogen bonds between bases on adjacent strands. Adenine (A) always pairs with thymine (T), while guanine (G) always pairs with cytosine (C). Adenine pairs with uracil (U) in RNA.



# FROM DNA TO PROTEINS

The bases on a single strand of DNA act as a code. The letters form three letter codons, which code for amino acids - the building blocks of proteins.



An enzyme, RNA polymerase, transcribes DNA into mRNA (messenger ribonucleic acid). It splits apart the two strands that form the double helix, then reads a strand and copies the sequence of nucleotides. The only difference between the RNA and the original DNA is that in the place of thymine (T), another base with a similar structure is used: uracil (U).

DNA SEQUENCE T T C C T G A A C C C G T T A

mRNA SEQUENCE U U C C U G A A C C C G U U A

**AMINO ACID** Phenylalanine Leucine Asparagine Proline Leucine

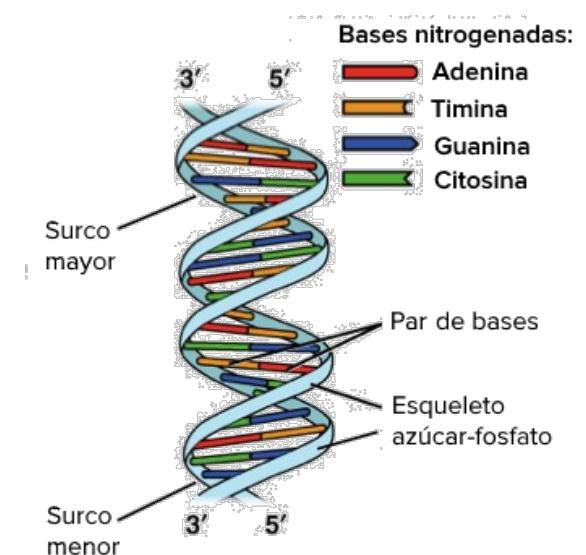
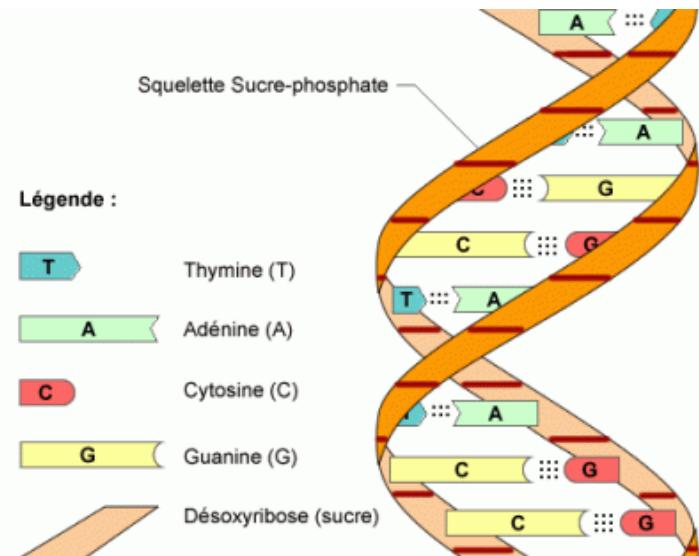
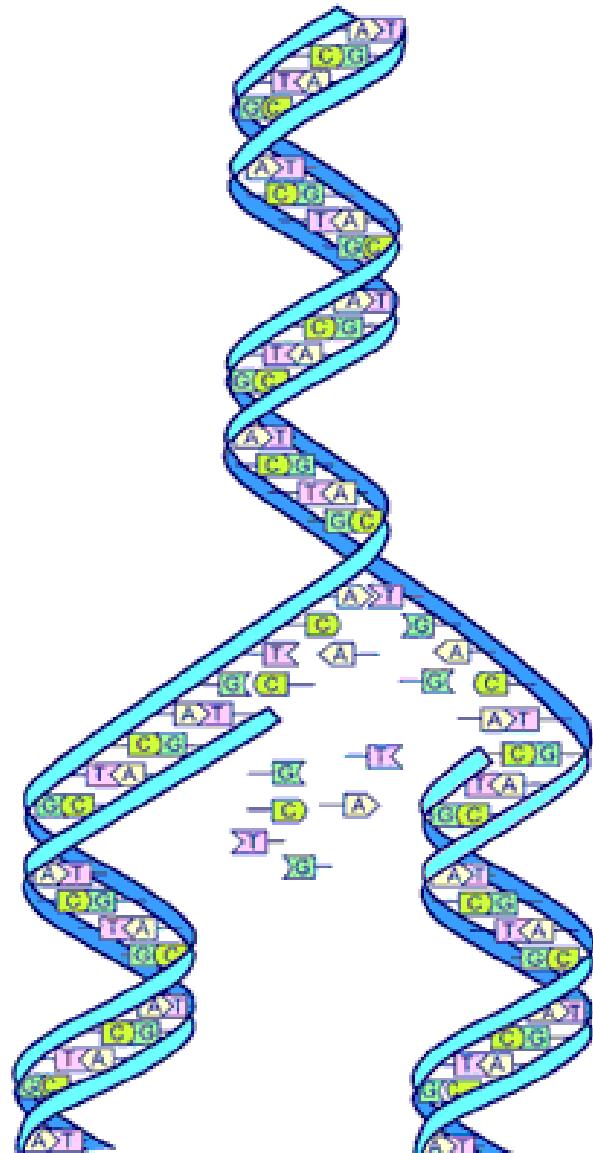
In multicellular organisms, the mRNA carries genetic code out of the cell nucleus, to the cytoplasm. Here, protein synthesis takes place. 'Translation' is the process of turning the mRNA's 'code' into proteins. Molecules called ribosomes carry out this process, building up proteins from the amino acids coded for.

# Replicación del ADN

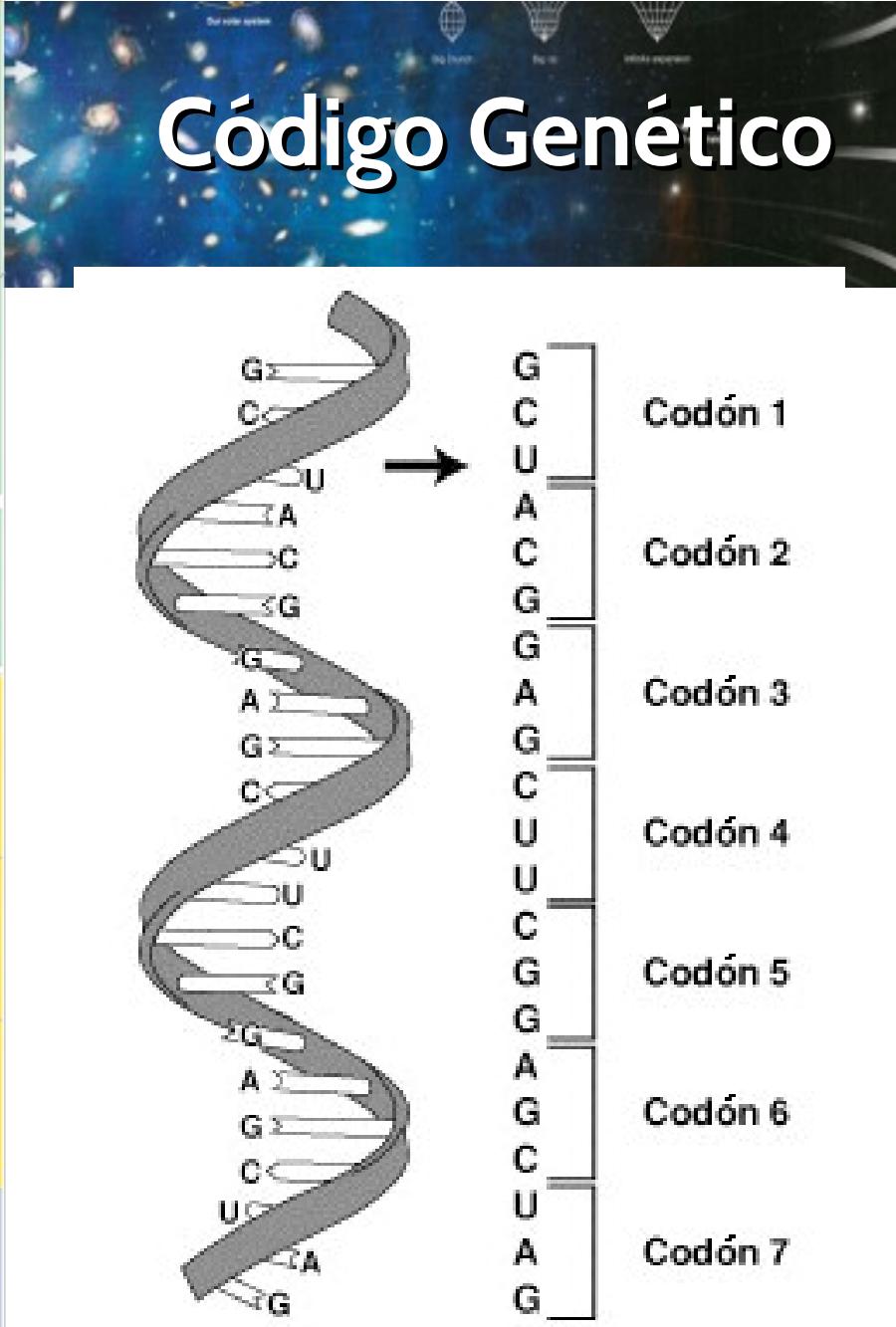
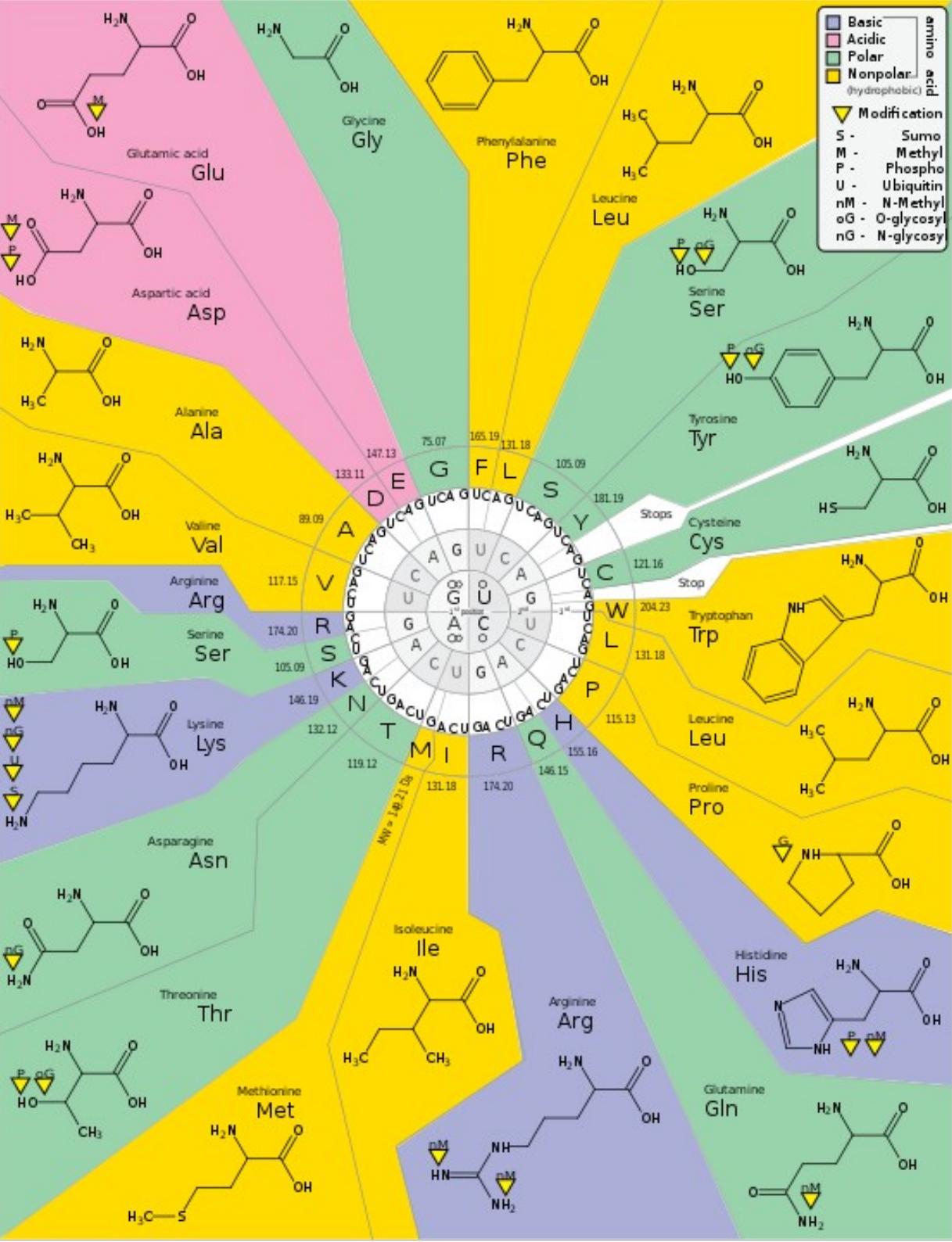


[www.dnalc.org](http://www.dnalc.org)

# No está retorcida, está enrollada....

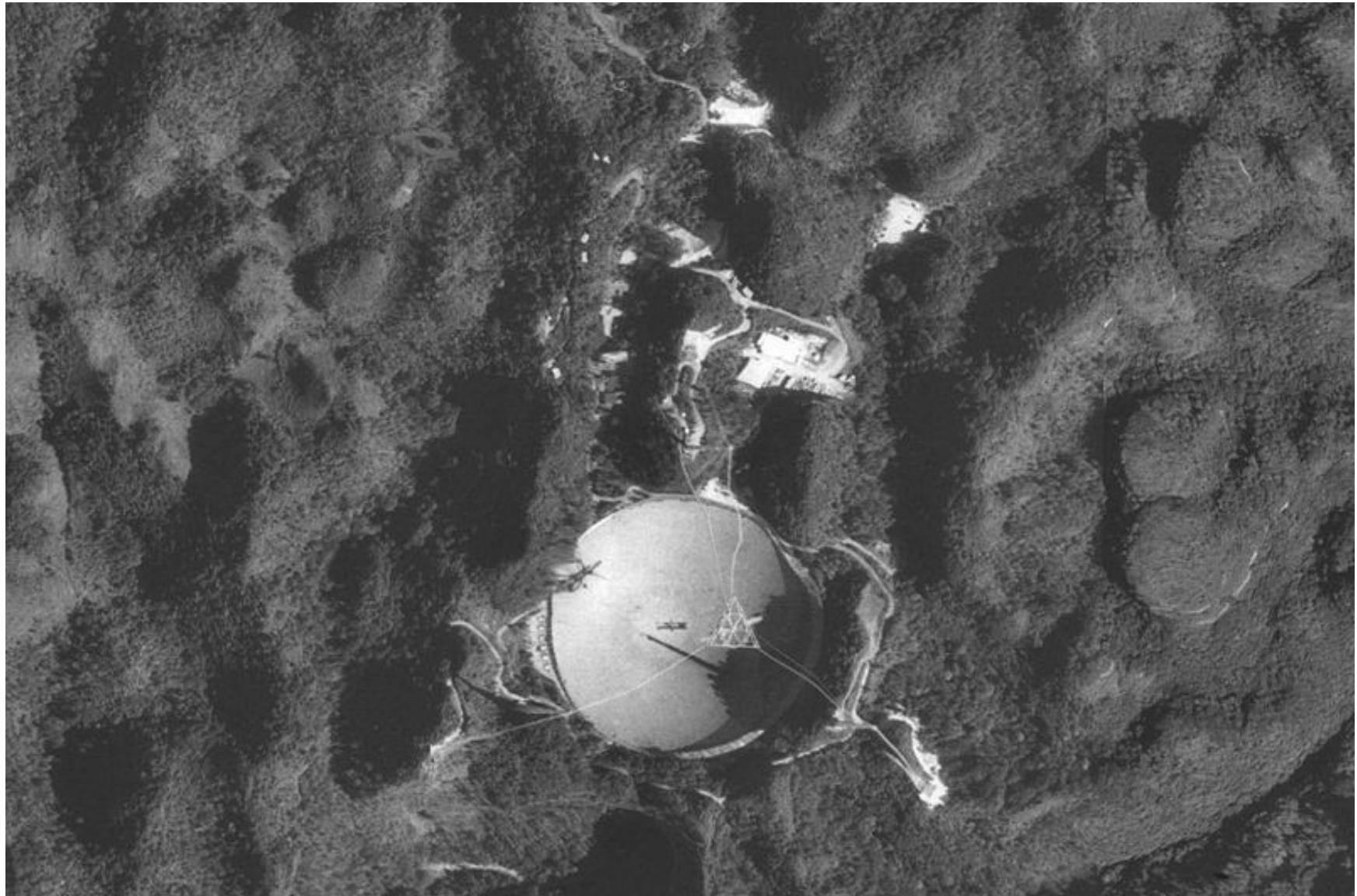


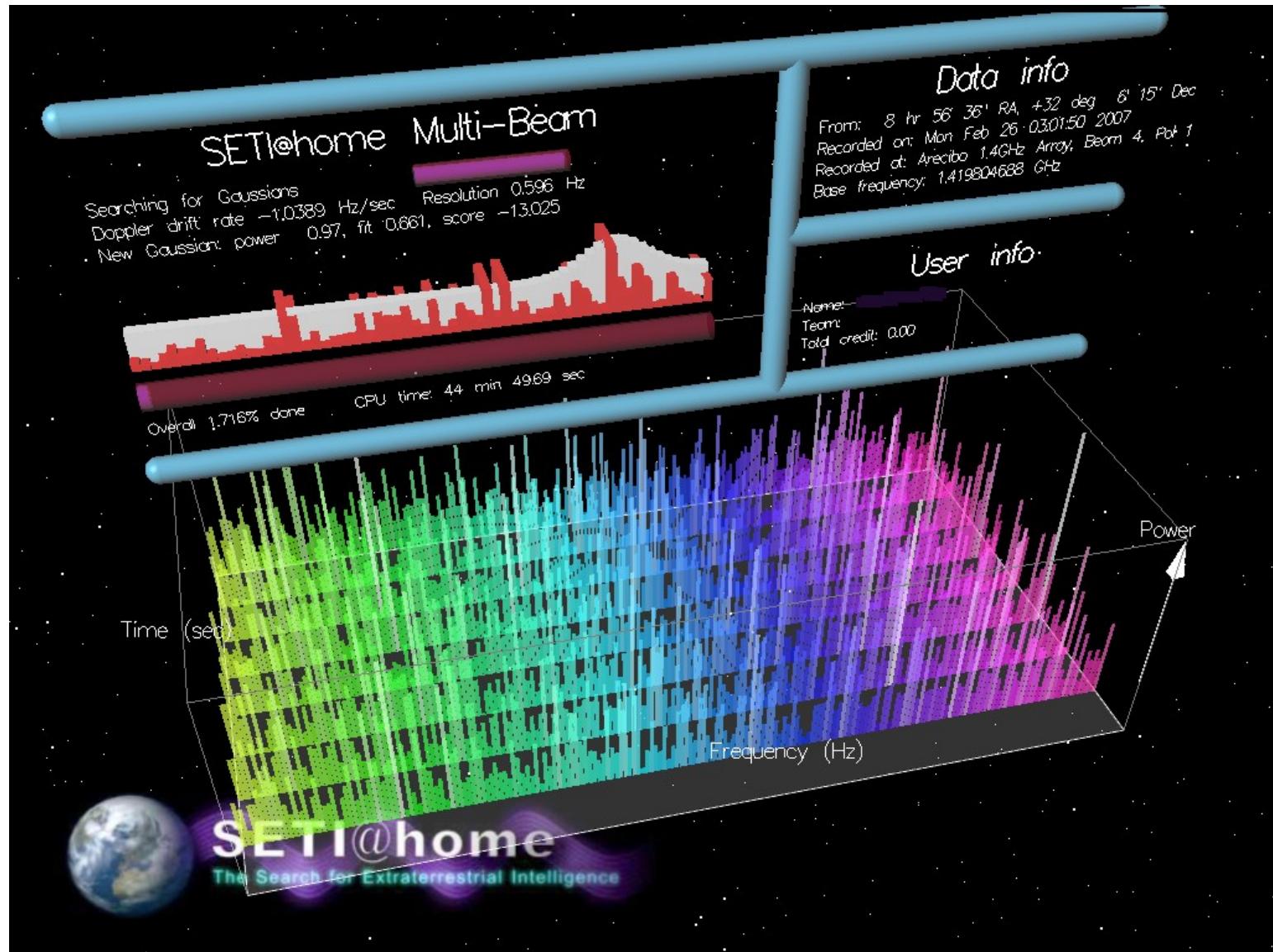
# Código Genético



B  
ARN  
Ácido ribonucleico

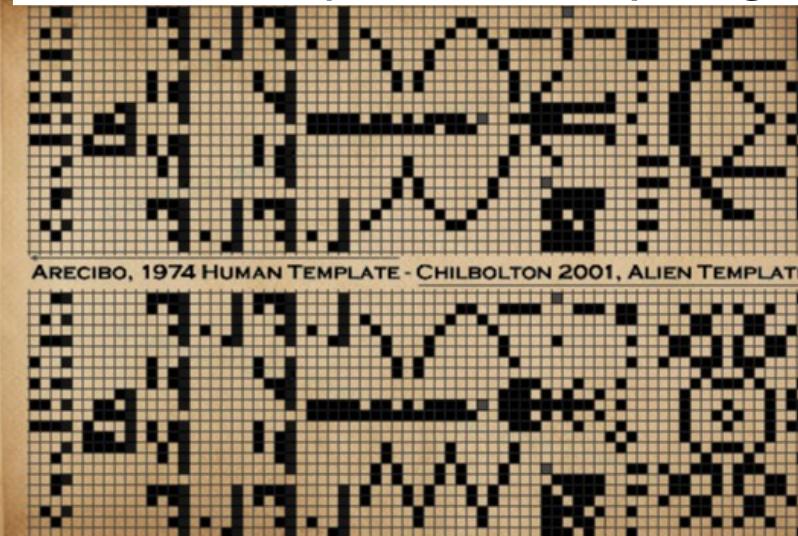
# SETI (Search for ExtraTerrestrial Intelligence)





# Mensaje de Arecibo

- 1679 bits enviados a M13 (8 kpc) (16/Nov/1974)
  - Diseñado por Carl Sagan y Frank Drake
  - Números 0 al 9 en binario
  - Componentes del ADN (HCNOP)
  - Nucleótidos y doble hélice
  - Humanidad, altura y población humana 1974
  - Sistema Solar (Sol y Planetas → Tamaño)
  - Telescopio, medidas y longitud de onda



# Ecuación de Drake (Frank Drake, 1961)

<https://www.spacecentre.nz/resources/tools/drake-equation-calculator.html>

- ¿Cuántas **civilizaciones inteligentes hay en este momento en nuestra galaxia ( $N$ )?**

- Estimación “a la Fermi”

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

- $N$  = Número de civilizaciones que pueden ser contactadas
- $R_*$  = Tasa promedio de formación estelar (en 1 / año)
- $f_p$  = fracción de estrellas con planetas
- $n_e$  = número promedio de planetas que pueden soportar vida
- $f_l$  = fracción de planetas que desarrollaron vida
- $f_i$  = fracción de los planetas que desarrollaron vida donde es inteligente
- $f_c$  = fracción de civilizaciones con tecnología de comunicación
- $L$  = tiempo que las civilizaciones emiten señales al espacio (años)

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

## La estimación de Drake

- $R_*$  = 1 estrella nueva / año (en realidad es mayor)
- $f_p$  = 0,2 - 0,5 (entre 1/5 y 1/2 de las estrellas forman planetas)
- $n_e$  = 1 - 5 planetas con capacidad de desarrollar y soportar vida
- $f_l$  = 1 (todos los planetas que pueden, desarrollan vida)
- $f_i$  = 1 (si hay vida, será inteligente)
- $f_c$  = 0,1 - 0,2 (10%-20% será capaz de comunicarse)
- $L$  =  $10^3$  -  $10^8$  años: tiempo que emitirán señales detectables
- Drake estimó  
$$(20 < N < 5 \times 10^7)$$
 civilizaciones

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

## Estimación moderna

- $R_* = 1,5 - 3$  estrellas nueva / año
- $f_p \sim 1$  (todas las estrellas forman planetas)
- $n_e = 3 - 5$  planetas capaces de desarrollar y soportar vida
- $f_l \sim 1$  (todos los planetas que pueden, desarrollan vida)
- $f_i \sim 1$  (si hay vida, es inevitable que se desarrolle inteligencia)
- $F_c = 0,2$  (20% será capaz de y querrá comunicarse)
- $L = 300$  años: tiempo que emitirán señales detectables
- Luego:  $N \sim 300-900$  civilizaciones en la galaxia

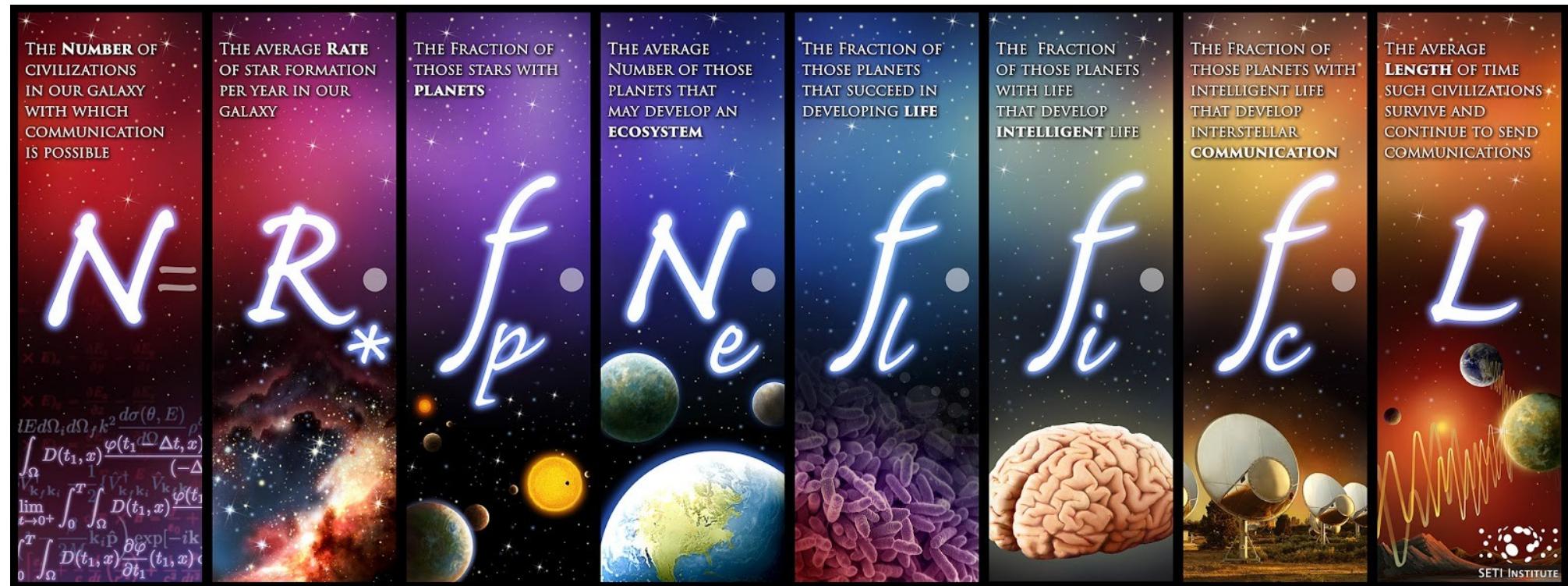
$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

## Rare Earth Hypothesis

- $R_* = 1,5 - 3$  estrellas nueva / año
- $f_p \cdot n_e \cdot F_l = 10^{-5}$  (fracción de planetas capaces de desarrollar vida *como la nuestra*)
- $f_i = 10^{-9}$  (es muy difícil tener vida inteligente)
- $f_c = 0,2$  (como Drake)
- $L = 300$  años
- Luego:  $N = 9,1 \times 10^{-13}$  civilizaciones en la galaxia :(
- Estamos sólos en la galaxia y probablemente en el Universo Observable

# La ecuación de Drake

<https://steemit.com/cervantes/@simonmaz/planetas-extrasolares-x--1526399175-5431302>



# THE DRAKE EQUATION

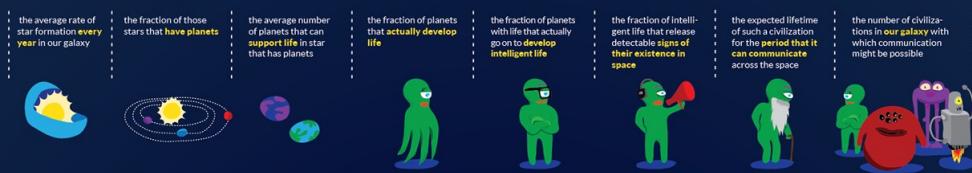
What is the Drake equation?

It's an equation developed by Frank Drake, that have the propose of estimate the potential number of intelligent alien civilizations in the our galaxy.

$$N = R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

How it does work?

$$R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times L = N$$

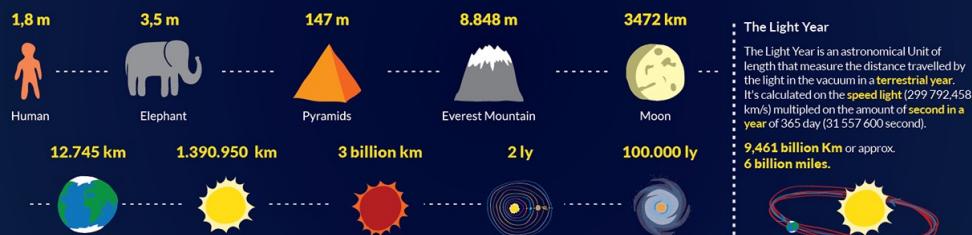


the following parameters are the actual and hypothetical values for the equation

$$7 \times 0,5 \times 2 \times 0,13 \times 0,01 \times 0,1 \times 10.000 = 23,1$$

The NASA and the European Space Agency calculate about 7 stars are born every year	Observation of the stars that look like the sun. 20-50% of these have planets	Using the Solar System as reference, only 2 planets match the condition for life.	The estimated number of planets where life evolves is around 0,13 and is based on the evolution of life on Earth.	On other planets that evolve life, intelligent species might be more advanced but in reality lower because with all the species on the Earth only one is intelligent	Observing the Earth, our signs in the space are really tiny and hard to find.	Based on the evolution of human civilization, we can see every culture takes a different path from the culture that came before, making the value for L potentially billions of years.	This result it's really low, considered the dimension of our galaxy. We are still in the chance of finding someone else are infinitesimal.
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Now is time to find out how big is the Milky Way, our galaxy.

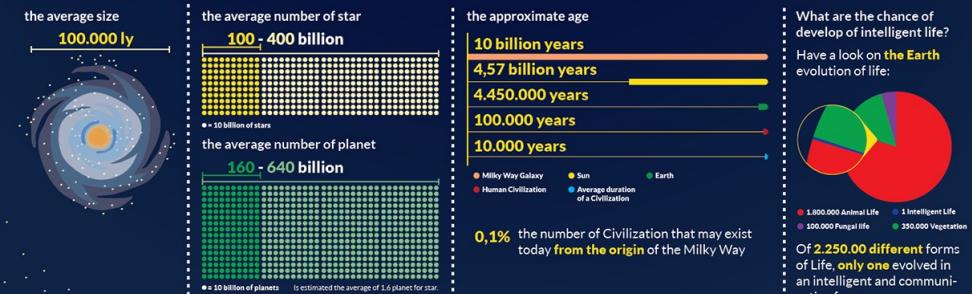


The Milky Way is really big, about 100.000 light year.

To understand the scale of size involved we will compare things getting bigger and bigger starting from the Man to the Milky Way.

As a guide to the relative physical scale of the Milky Way, if were reduced to 130 kilometers in diameter, the Solar System, would be no more than 2 millimeter in width, like a grain of sand in a sports field.

Some facts about the Milky Way Galaxy



# Para jóvenes

- El autor recomienda esta infografía para jóvenes de 10-14 años
- Incluye información sobre la vía láctea y órdenes de magnitud
- Ver en <https://www.behance.net/gallery/4137925/The-DRAKE-Equation>

# Esferas de Dyson



# IRAS (InfraRed Astronomical Satellite)

[http://home.fnal.gov/~carrigan/infrared\\_astronomy/Fermilab\\_search.htm](http://home.fnal.gov/~carrigan/infrared_astronomy/Fermilab_search.htm)

