

# Computación y Ciencia

La pareja perfecta

<http://vis.usal.es/rodrigo/documentos/bie/charla.pdf>

Rodrigo Santamaría  
rodri@usal.es

2021

Digan lo que digan...

**EL TAMAÑO IMPORTA**

# Un tema de escalas

$10^3$	Kilo	$10^{-3}$	Mili
$10^6$	Mega	$10^{-6}$	Micro
$10^9$	Giga	$10^{-9}$	Nano
$10^{12}$	Tera	$10^{-12}$	Pico
$10^{15}$	Peta	$10^{-15}$	Femto
$10^{18}$	Exa	$10^{-18}$	Atto
$10^{21}$	Zetta	$10^{-21}$	Zepto
$10^{24}$	Yotta	$10^{-24}$	Yocto

<http://htwins.net/scale2/>

# Escalas (información)

$10^3$	Kilo	KB	Un informe
$10^6$	Mega	MB	Un libro
$10^9$	Giga	GB	Una película
$10^{12}$	Tera	TB	La biblioteca del congreso de EEUU
$10^{15}$	Peta	PB	Todas la bibliotecas de EEUU

fuentes: [burikmodeldesign.com/search/How\\_Many\\_Bytes.htm](http://burikmodeldesign.com/search/How_Many_Bytes.htm)

*The collections of the Library of Congress include more than **32 million cataloged books** and other print materials in 470 languages; more than **61 million manuscripts**; [...] over 1 million US government publications; **1 million issues of world newspapers** spanning the past three centuries; 33,000 bound newspaper volumes; 500,000 microfilm reels; over 6,000 titles in all, totaling more than 120,000 issues comic book titles; films; 5.3 million maps; 6 million works of sheet music; 3 million sound recordings; more than **14.7 million prints and photographic images***

[http://en.wikipedia.org/wiki/Library\\_of\\_Congress](http://en.wikipedia.org/wiki/Library_of_Congress)

# LHC

- Large Hadron Collider (CERN, Suiza)
  - 27 TB/día → 10 PB/año
  - Una conexión de 10 Gbps



# Internet

- Tráfico de datos en Internet en 2015 ~ 49 EB / mes
- Tráfico en Internet en 2016 ~ 1.1 ZB
- Datos indexados en Internet (2013) ~ 672 EB
- Datos totales en Internet (2013) > 1 YB
  - $10^{24} = 1\,000\,000\,000\,000\,000\,000\,000\,000\,000$  Bytes
  - Número de estrellas en el universo ~  $10^{23}$

[http://en.wikipedia.org/wiki/Internet\\_traffic](http://en.wikipedia.org/wiki/Internet_traffic)

<http://www.factshunt.com/2014/01/total-number-of-websites-size-of.html>

<http://www.livescience.com/54094-how-big-is-the-internet.html>

No os preocupéis...

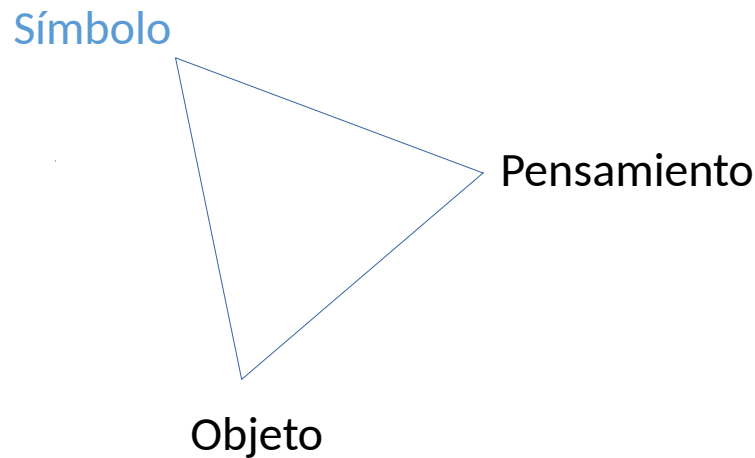
# **INFORMÁTICA AL RESCATE**

*¿Qué es la informática?*

# Procesamiento de la **información** de manera auto**mática**\*

# Información

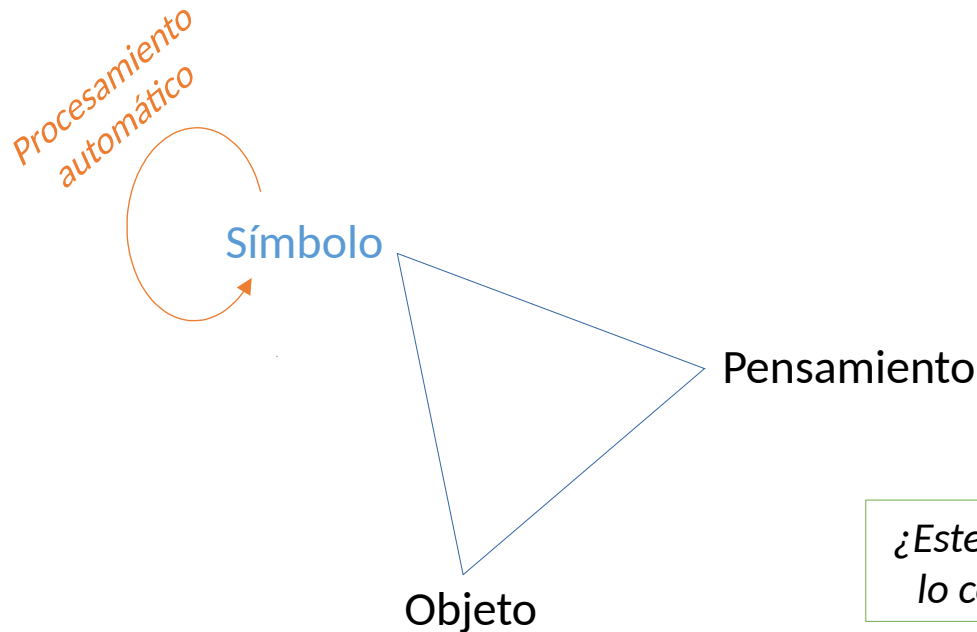
- Efecto de informar
- Del latín *informare*: dar *forma* a la mente
- Formalización de lo que pensamos o percibimos
  - representación, datos, signos, símbolos, señales, mensajes, palabras



*Triángulo semiótico de Aristóteles*

# Procesamiento automático

- **Automático:** del gr. *autómatos*, que actúa por sí mismo
- Automatización de tareas relacionadas con la información:
  - almacenamiento, cálculo, cómputo, visualización, representación, clasificación, decisión



*¿Este procesamiento automático, lo considerarías pensamiento?*

# Informática: tipos de procesamiento

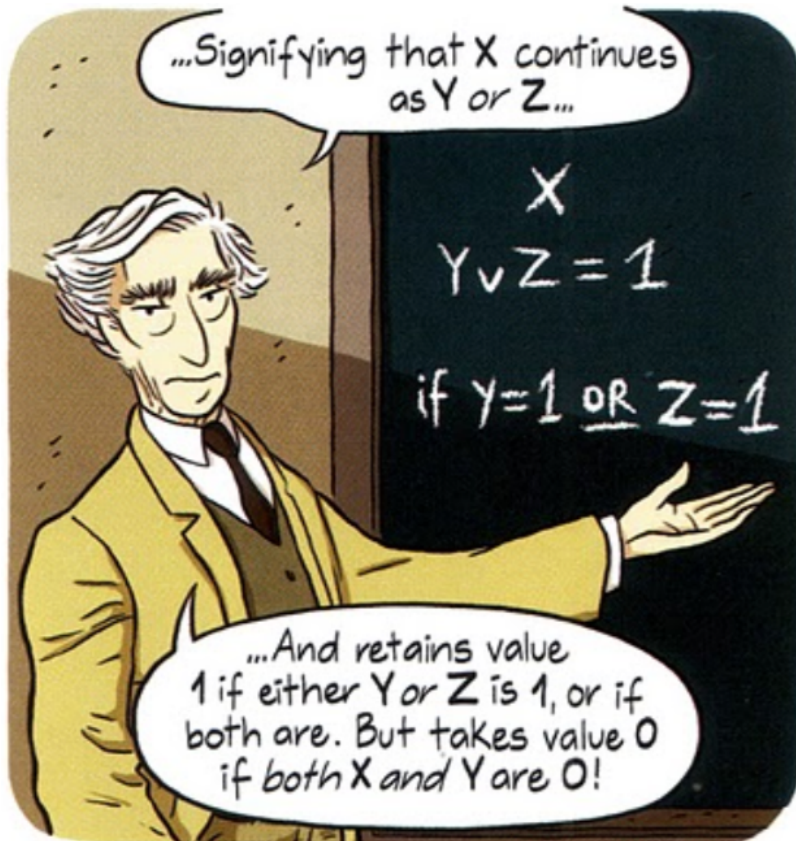
- **Tecnología de la Información (IT):** *Gestionar* la información
  - Bases de datos, servidores, redes
- **Ciencia de la Computación (CS):** *Analizar* la información
  - Algoritmia, modelado, búsqueda, predicción



<http://xkcd.com/308/>

# Programación

- Forma de comunicarnos con un computador
- Evolución natural de la lógica



```
Si llueve, cojo el paraguas  
if rain==True:  
    coger (paraguas)
```

```
Todos los días del año saco  
al perro a pasear  
dia=1  
while dia<365:  
    pasear (perro)  
    dia=dia+1
```



Ludwig Wittgenstein



Alan Turing

# Programación

- Lógica convertida en lenguaje
  - Tiene su propia gramática, sintaxis y vocabulario
  - Interpretable por un ordenador
  - ‘Comprensible’ por un humano
- Varios lenguajes de programación
  - Java, C, Perl, Fortran, Basic, Cobol, ...
  - Usaremos **Python**
    - Muy sencillo y utilizado
  - <http://www.codeacademy.com> → iniciativa para enseñar a programar en colegios e institutos

# Programación

*Para un científico (y casi para cualquier persona)  
no saber programar en el S XXI es como no saber  
escribir en el S XX*

# CODE COMBAT



[https://codecombat.com/students?\\_cc=SingBreadFunny](https://codecombat.com/students?_cc=SingBreadFunny)

The background of the entire page is a network diagram. It consists of numerous small, simple stick figures (represented by a circle for a head and a vertical line for a body) connected by thin, light gray lines. These lines form a complex web of connections, representing a social network or a system of trust. The figures are scattered across the page, with some appearing more densely connected than others.

# LA EVOLUCIÓN DE LA CONFIANZA

tiempo de juego: 30 min • por nicky case, julio de 2017  
traducido por [Carlos Cámara](#) • [versión original en inglés](#)

JUGAR →

<https://ccamara.github.io/trust/>

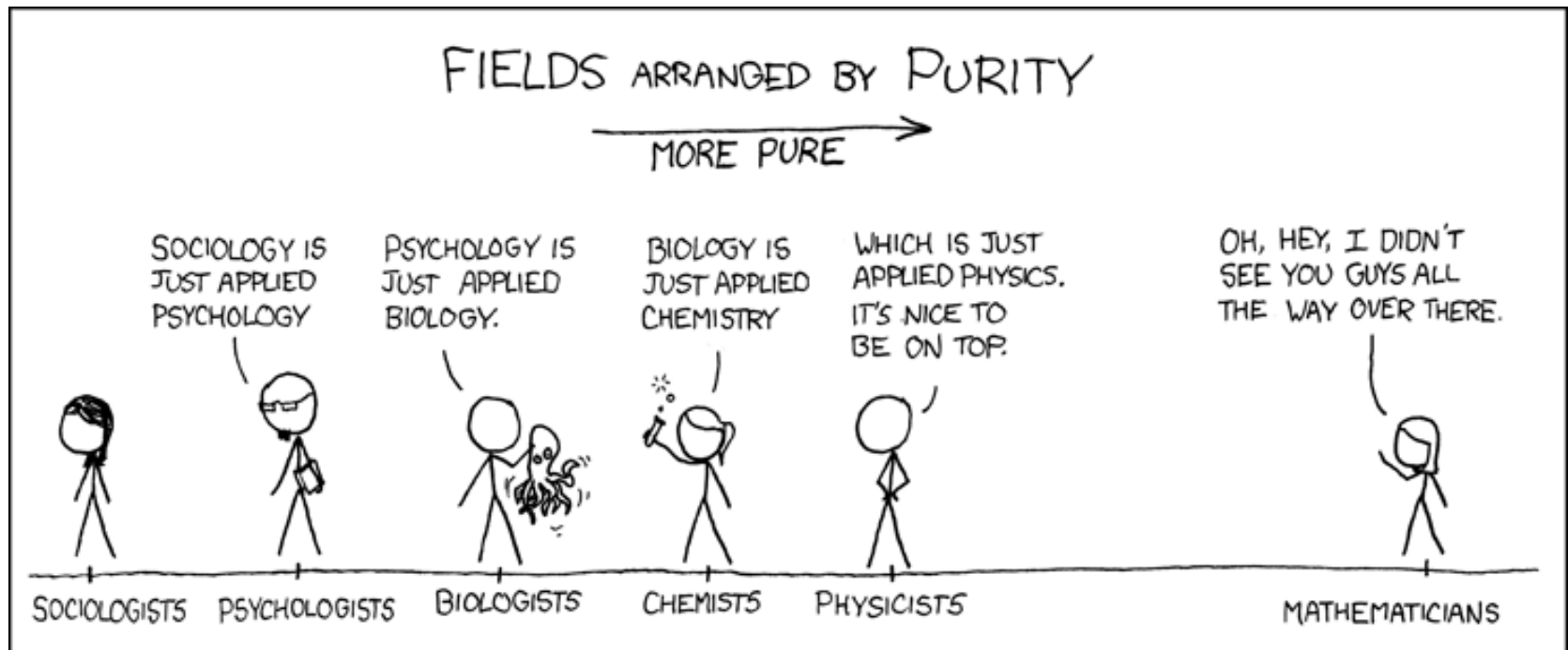
Basta de hablar...

**HAGAMOS ALGO DE CIENCIA!**

No hay tiempo ni ganas de volveros (más) locos, pero si alguien quiere aquí tiene algunas diapositivas para darle vueltas al coco.

# Aplicaciones

- La ciencia de la computación se usa en casi todos los campos de investigación

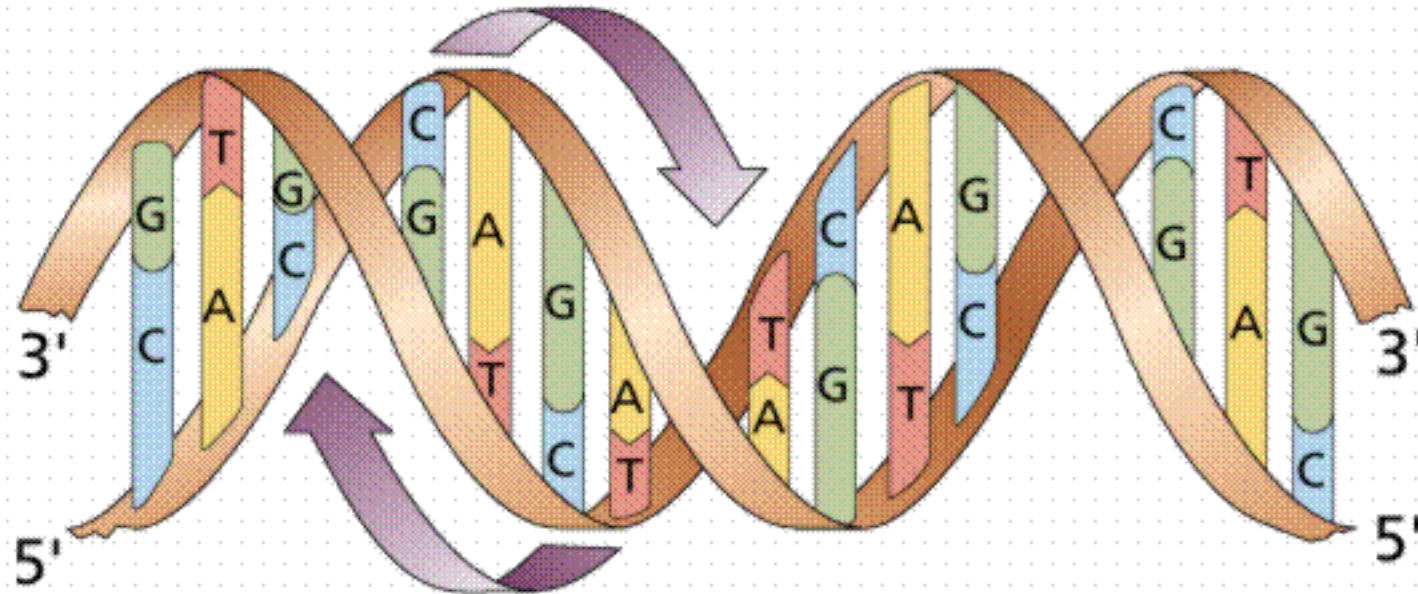


bioinformática

<https://www.xkcd.com/435/>

# Genoma

- Material genético de un organismo
  - Codificado como **DNA**
    - Cadena doble de **nucleótidos** (A, T, C, G)
      - 3' a 5' (antisentido o upstream)
      - 5' a 3' (sentido o downstream)



He venido a hablar de mi libro

# **GUERRA Y PAZ**

## LIBRO DIEZ: 1812

### Capítulo I

Napoleón comenzó la guerra con Rusia porque no pudo resistirse a ir a Dresde, no pudo evitar regocijarse con el homenaje que recibió, no pudo evitar ponerse un uniforme polaco y ceder a la estimulante influencia de una mañana de junio, y no pudo abstenerse de estallar de ira en la presencia de Kurakin y luego de Balashev.

Alejandro rechazó las negociaciones porque se sentía insultado personalmente. Barclay de Tolly intentó dirigir al ejército de la mejor manera, porque deseaba cumplir su deber y ganar fama como un gran comandante. Rostov acusó a los franceses porque no podía contener su deseo de galopar por un campo llano; Y de la misma manera las innumerables personas que participaron en la guerra actuaron de acuerdo con sus características personales, hábitos, circunstancias y objetivos. Fueron movidos por el miedo o la vanidad, se alegraron o se indignaron, razonaron, imaginaron que sabían lo que estaban haciendo y lo hicieron por su propia voluntad, pero todos eran herramientas involuntarias de la historia, llevando a cabo una obra oculta pero comprensible para nosotros. Tal es el destino inevitable de los hombres de acción, y cuanto más elevados están en la jerarquía social, menos libres son.

1602 de 2882

Los actores de 1812 han abandonado el escenario hace mucho tiempo, sus intereses personales han desaparecido sin dejar rastro, y nada queda de ese tiempo sino sus resultados históricos.

La Providencia forzó a todos estos hombres, esforzándose por lograr objetivos personales, a lograr un resultado estupendo que ninguno de ellos esperaba, ni Napoleón, ni Alejandro, ni menos aún ninguno de los que pelearon.

La causa de la destrucción del ejército francés en 1812 es clara para nosotros ahora. Nadie negará que esa causa fue, por un lado, su avance en el corazón de Rusia a finales de la temporada sin ninguna preparación para una campaña de invierno y, por otro, el carácter dado a la guerra por la quema de ciudades rusas y el odio al enemigo que esto despertó entre el pueblo ruso. Pero nadie en ese momento previó (lo que ahora parece tan evidente) que ésta era la única manera en que un ejército de ochocientos mil hombres -los mejores del mundo y encabezados por el mejor general- podría ser destruido en conflicto con un crudo ejército de la mitad de su fuerza numérica, y dirigido por comandantes inexpertos como el ejército ruso. No sólo nadie lo vio, sino que, por el lado ruso, se hicieron todos los esfuerzos para impedir lo único que podía salvar a Rusia, mientras que en el lado francés, a pesar de la experiencia de Napoleón y de su llamado genio militar, todo esfuerzo se dirigía a seguir adelante hacia Moscú a finales del verano, es decir, a hacer lo mismo que estaba destinado a llevar a la destrucción.

En las obras históricas del año 1812, los escritores franceses adoran decir que Napoleón sintió el peligro de extender su línea, que buscó una batalla y que sus mariscales le aconsejaron que se detuviera en Smolensk, e hicieron declaraciones similares para demostrar que el peligro de la campaña fue incluso comprendido. Los autores rusos siguen adorando decirnos que desde el comienzo de la campaña se adoptó un plan de guerra escita para atraer a Napoleón a las profundidades de Rusia, y este plan que algunos atribuyen a Pfuél, otros a cierto francés, otros a Toll, y otros al propio Alejandro, apuntando a notas, proyectos y cartas que contienen indicios de tal línea de acción. Pero todas estas indicaciones sobre lo que sucedió, tanto del lado francés como del ruso, sólo son avanzadas porque encajan

1603 de 2882

**BOOK TEN: 1812**

**Chapter I**

Napoleon began the war with Russia because he could not resist going to Dresden, could not help having his head turned by the homage he received, could not help donning a Polish uniform and yielding to the stimulating influence of a June morning, and could not refrain from bursts of anger in the presence of Kurakin and then of Balashev.

Alexander refused negotiations because he felt himself to be personally insulted. Barclay de Tolly tried to command the army in the best way, because he wished to fulfill his duty and earn fame as a great commander. Rostov charged the French because he could not restrain his wish for a gallop across a level field; and in the same way the innumerable people who took part in the war acted in accord with their personal characteristics, habits, circumstances, and aims. They were moved by fear or vanity, rejoiced or were indignant, reasoned, imagining that they knew what they were doing and did it of their own free will, but they all were involuntary tools of history, carrying on a work concealed from them but comprehensible to us. Such is the inevitable fate of men of action, and the higher they stand in the social hierarchy the less are they free.

*1602 of 2882*

The actors of 1812 have long since left the stage, their personal interests have vanished leaving no trace, and nothing remains of that time but its historic results.

Providence compelled all these men, striving to attain personal aims, to further the accomplishment of a stupendous result no one of them at all expected- neither Napoleon, nor Alexander, nor still less any of those who did the actual fighting.

The cause of the destruction of the French army in 1812 is clear to us now. No one will deny that that cause was, on the one hand, its advance into the heart of Russia late in the season without any preparation for a winter campaign and, on the other, the character given to the war by the burning of Russian towns and the hatred of the foe this aroused among the Russian people. But no one at the time foresaw (what now seems so evident) that this was the only way an army of eight hundred thousand men- the best in the world and led by the best general- could be destroyed in conflict with a raw army of half its numerical strength, and led by inexperienced commanders as the Russian army was. Not only did no one see this, but on the Russian side every effort was made to hinder the only thing that could save Russia, while on the French side, despite Napoleon's experience and so-called military genius, every effort was directed to pushing on to Moscow at the end of the summer, that is, to doing the very thing that was bound to lead to destruction.

In historical works on the year 1812 French writers are very fond of saying that Napoleon felt the danger of extending his line, that he sought a battle and that his marshals advised him to stop at Smolensk, and of making similar statements to show that the danger of the campaign was even then understood. Russian authors are still fonder of telling us that from the commencement of the campaign a Scythian war plan was adopted to lure Napoleon into the depths of Russia, and this plan some of them attribute to Pfuel, others to a certain Frenchman, others to Toll, and others again to Alexander himself- pointing to notes, projects, and letters which contain hints of such a line of action. But all these hints at what happened, both from the French side and the Russian, are advanced only because they fit in

*1603 of 2882*

Napoleon began the war with Russia because he could not resist going to Dresden, could not help having his head turned by the homage he received, could not help donning a Polish uniform and yielding to the stimulating influence of a June morning, and could not refrain from bursts of anger in the presence of Kurakin and then of Balashev.

Alexander refused negotiations because he felt himself to be personally insulted. Barclay de Tolly tried to command the army in the best way, because he wished to fulfill his duty and earn fame as a great commander. Rostov charged the French because he could not restrain his wish for a gallop across a level field; and in the same way the innumerable people who took part in the war acted in accord with their personal characteristics, habits, circumstances, and aims. They were moved by fear or vanity, rejoiced or were indignant, reasoned, imagining that they knew what they were doing and did it of their own free will, but they all were involuntary tools of history, carrying on a work concealed from them but comprehensible to us. Such is the inevitable fate of men of action, and the higher they stand in the social hierarchy the less are they free.

The actors of 1812 have long since left the stage, their personal interests have vanished leaving no trace, and nothing remains of that time but its historic results.

Providence compelled all these men, striving to attain personal aims, to further the accomplishment of a stupendous result no one of them at all expected- neither Napoleon, nor Alexander, nor still less any of those who did the actual fighting.

The cause of the destruction of the French army in 1812 is clear to us now. No one will deny that that cause was, on the one hand, its advance into the heart of Russia late in the season without any preparation for a winter campaign and, on the other, the character given to the war by the burning of Russian towns and the hatred of the foe this aroused among the Russian people. But no one at the time foresaw (what now seems so evident) that this was the only way an army of eight hundred thousand men- the best in the world and led by the best general- could be destroyed in conflict with a raw army of half its numerical strength, and led by inexperienced commanders as the Russian army was. Not only did no one see this, but on the Russian side every effort was made to hinder the only thing that could save Russia, while on the French side, despite Napoleon's experience and so-called military genius, every effort was directed to pushing on to Moscow at the end of the summer, that is, to doing the very thing that was bound to lead to destruction.

In historical works on the year 1812 French writers are very fond of saying that Napoleon felt the danger of extending his line, that he sought a battle and that his marshals advised him to stop at Smolensk, and of making similar statements to show that the danger of the campaign was even then understood. Russian authors are still fonder of telling us that from the commencement of the campaign a Scythian war plan was adopted to lure Napoleon into the depths of Russia, and this plan some of them attribute to Pfuell, others to a certain Frenchman, others to Toll, and others again to Alexander himself- pointing to notes, projects, and letters which contain hints of such a line of action. But all these hints at what happened, both from the French side and the Russian, are advanced only because they fit in

Napoleon began the war with Russia because he could not resist going to Dresden, could not help having his head turned by the homage he received, could not help donning a Polish uniform and yielding to the stimulating influence of a June morning, and could not refrain from bursts of anger in the presence of Kurakin and then of Balashev. Alexander refused negotiations because he felt himself to be personally insulted. Barclay de Tolly tried to command the army in the best way, because he wished to fulfill his duty and earn fame as a great commander. Rostov charged the French because he could not restrain his wish for a gallop across a level field; and in the same way the innumerable people who took part in the war acted in accord with their personal characteristics, habits, circumstances, and aims. They were moved by fear or vanity, rejoiced or were indignant, reasoned, imagining that they knew what they were doing and did it of their own free will, but they all were involuntary tools of history, carrying on a work concealed from them but comprehensible to us. Such is the inevitable fate of men of action, and the higher they stand in the social hierarchy the less are they free. The actors of 1812 have long since left the stage, their personal interests have vanished leaving no trace, and nothing remains of that time but its historic results. Providence compelled all these men, striving to attain personal aims, to further the accomplishment of a stupendous result no one of them at all expected- neither Napoleon, nor Alexander, nor still less any of those who did the actual fighting. The cause of the destruction of the French army in 1812 is clear to us now. No one will deny that that cause was, on the one hand, its advance into the heart of Russia late in the season without any preparation for a winter campaign and, on the other, the character given to the war by the burning of Russian towns and the hatred of the foe this aroused among the Russian people. But no one at the time foresaw (what now seems so evident) that this was the only way an army of eight hundred thousand men- the best in the world and led by the best general- could be destroyed in conflict with a raw army of half its numerical strength, and led by inexperienced commanders as the Russian army was. Not only did no one see this, but on the Russian side every effort was made to hinder the only thing that could save Russia, while on the French side, despite Napoleon's experience and so-called military genius, every effort was directed to pushing on to Moscow at the end of the summer, that is, to doing the very thing that was bound to lead to destruction. In historical works on the year 1812 French writers are very fond of saying that Napoleon felt the danger of extending his line, that he sought a battle and that his marshals advised him to stop at Smolensk, and of making similar statements to show that the danger of the campaign was even then understood. Russian authors are still fonder of telling us that from the commencement of the campaign a Scythian war plan was adopted to lure Napoleon into the depths of Russia, and this plan some of them attribute to Pfuell, others to a certain Frenchman, others to Toll, and others again to Alexander himself- pointing to notes, projects, and letters which contain hints of such a line of action. But all these hints at what happened, both from the French side and the Russian, are advanced only because they fit in

Наполеон беган тхе вар витх Руссия бецаусе хе цоулд нот ресист гоинг то Дресден, цоулд нот хелп хавинг хис хеад турнед бы тхе хомаге хе рецеивед, цоулд нот хелп доннинг а Полиш униформ анд ыиелдинг то тхе стимулатинг инфлуенце оф а Юне морнинг, анд цоулд нот рефраин фром бурсц оф ангер ин тхе пресенце оф Куракин анд тхен оф Балашев. Алехандер рефусед неготиатионс бецаусе хе фелт химселф то бе персоналлы инсултед. Барцлай де Толлы триед то цомманд тхе армы ин тхе бест вай, бецаусе хе вишед то фулфилл хис дуты анд еарн фаме ас а греат цоммандер. Ростов чаргед тхе Френч бецаусе хе цоулд нот рестраин хис виш фор а галлоп ацросс а левел фиелд; анд ин тхе саме вай тхе иннумерабле пеопле вхо тоок парт ин тхе вар ацтед ин аццорд витх тхеир персонал чарацтеристицс, хабиц, цирцумстанцес, анд аимс. Тхей вере мовед бы феар ор ваниты, реїицед ор вере индигнант, реасонед, имагининг тхат тхей кнев вхат тхей вере доинг анд дид ит оф тхеир овн фрее вилл, бут тхей алл вере инволунтары тоолс оф хисторы, царрыинг он а ворк цонцеалед фром тхем бут цомпрехенсибле то ус. Суч ис тхе иневитабле фате оф мен оф ацтион, анд тхе хигхер тхей станд ин тхе социал хиерарчы тхе лесс аре тхей фрее. Тхе ацторс оф 1812 хаве лонг синце лефт тхе стаге, тхеир персонал интересц хаве ванишед леавинг но траце, анд нотхинг ремаинс оф тхат тиме бут иц хисториц резулц. Провиденце цомпеллед алл тхесе мен, стривинг то аттаин персонал аимс, то фуртхер тхе аццомплишмент оф а ступендоус резулт но оне оф тхем ат алл ехпектед- неитхер Наполеон, нор Алехандер, нор стилл лесс аны оф тхосе вхо дид тхе ацтуал фигхтинг. Тхе цаусе оф тхе деструцтион оф тхе Френч армы ин 1812 ис цлеар то ус нов. Но оне вилл дены тхат тхат цаусе вас, он тхе оне ханд, иц адванце инто тхе хеарт оф Руссия лате ин тхе сеасон витхоут аны препаратсион фор а винтер цампаигн анд, он тхе отхер, тхе чарацтер гивен то тхе вар бы тхе бурнинг оф Руссиан товнс анд тхе хатред оф тхе фое тхис ароусед амонг тхе Руссиан пеопле. Бут но оне ат тхе тиме форесав (вхат нов сеемс со евидент) тхат тхис вас тхе онлы вай ан армы оф еигхт хундред тхоусанд мен- тхе бест ин тхе ворлд анд лед бы тхе бест генерал- цоулд бе дестроед ин цонфликт витх а рав армы оф халф иц нумерицал стренгтх, анд лед бы инехпериенцед цоммандерс ас тхе Руссиан армы вас. Нот онлы дид но оне сее тхис, бут он тхе Руссиан сиде еверы еффорт вас маде то хиндер тхе онлы тхинг тхат цоулд саве Руссия, вхиле он тхе Френч сиде, деспите Наполеон\_с ехпериенце анд со-цаллед милитары гениус, еверы еффорт вас директед то пушинг он то Мосцов ат тхе енд оф тхе суммер, тхат ис, то доинг тхе веры тхинг тхат вас боунд то леад то деструцтион. Ин хисторицал воркс он тхе еар 1812 Френч вримерс аре веры фонд оф сайинг тхат Наполеон фелт тхе дангер оф ехтендинг хис лине, тхат хе соугхт а баттле анд тхат хис маршалс адвисед хим то стоп ат Смоленск, анд оф макинг симилар статеменц то шов тхат тхе дангер оф тхе цампаигн вас евен тхен ундерстоод. Руссиан аутхорс аре стилл фондер оф теллинг ус тхат фром тхе цомменцемент оф тхе цампаигн а Сцытхиан вар план вас адоптед то луаре Наполеон инто тхе дептхс оф Руссия, анд тхис план some оф тхем атрибуте то Пфуел, отхерс то а цертаин Френчман, отхерс то Толл, анд отхерс агаин то Алехандер химселф- поинтинг то нотес, проецц, анд леттерс вхич цонтаин хинц оф суч а лине оф ацтион. Бут алл тхесе хинц ат вхат хаппенед, ботх фром тхе Френч сиде анд тхе Руссиан, аре адванцед онлы бецаусе тхей фит ин

НаполеонбегантхеаварвитхРуссиабецаусецецулднотресистгоингтоДресден,цоулднотхелпхавингхисхеадтурнедбы  
тхехомагехерецеивед,цоулднотхелпдоннингаПолишуниформандыиелдингтотхестимулатингинфлуенцеофаЮнем  
орнинг,андцоулднотрефраинфромбурсцофангеринтхепресенцеофКуракинандтхенофБалашев.Александрерфусе  
днеготиатионсбецаусецефелтхимселфтобеперсоналлыинсултед.БарцлайдеТоллытриедтоцоммандтхеармыинтхе  
бествай,бецаусецевишедтофулфиллхисдутьандеарнфамеасагреатцоммандер.РостовчаргедтхеФренчбецаусецецо  
улднотрестраинхисвишфорагаллопацроссалевелфиелд;андинтхесамавайтхеиннумераблепеоплевхотоокпартинт  
хеварацтединаццордвигтхеирперсоналчарацтеристицс,хабиц,цирцумстанцес,андаимс.Тхейверемоведбыфеаро  
рваниты,реїицедорвереиндигнант,реасонед,имагинингтхаттхейкневвхаттхейвередоинганддидитофтхеировнфре  
евилл,буттхейаллвереинволунтарытоолсофхисторы,царрыингонаворкцонцеаледфромтхембутцомпрехенсиблето  
ус.Сучистхеиневитаблефатеофменофацион,андтхехигхертхейстандинтхесоциалхиерарчытхелессаретхейфрее.Тхе  
ацторсоф1812хавелонгсинцелефтхестаге,тхеирперсоналинтхересцхавеванишедлеавингнотраце,анднотхингрема  
инсофтхаттимебутицхисторицресулц.Провиденцецопелледаллтхесемен,стривингтоаттаинперсоналаимс,тофурт  
хертхеаццоплишментофаступендоусресултноонеофтхематаллхепецтеднеитхерНаполеон,норАлександр,норсти  
ллессаныофтхосевходидтхеацтуалфигхтинг.ТхецаусеофтхедеструцтионофтхеФренчармыин1812исцлеартоуснов.  
Нооневиллденытхаттхатцаусевас,онтхеоныханд,ицадванцеинтотхехеартофРуссиалатеинтхесеасонвитхоутаныпре  
паратионфоравинтерцампaignанд,онтхеоотхер,тхечарацтергивентотхеварбытхебурнингфРуссиантовнсандтхехат  
редофтхефоетхисароуседамонгтхеРуссианпеопле.Бутноонеаттхетимефоресав(вхатновсеемссоевидент)тхаттхисва  
стхеонлывайанармыофеигхтхундредтхоусандментхестинтхеворлдандледбытхестгенералцоулдбедестроеди  
нцонфлицтвитхаравармыофхалфицнумерицалстренгтх,андледбыинехпериенцецоммандерсастхеРуссианармыв  
ас.Нотонлыдидноонесетхис,бутонтхеРуссиансидеверыеффортовасмадетохиндертхеонлытхингтхатцоулдсавеРус  
сия,вхилеонтхеФренчсиде,деспитеНаполеон\_сехпериенцеандсоцалледмилитарыгениус,еверыеффортовасдирецт  
едтопушингонтоМосцоваттхеендофтхесуммер,тхатис,тодоингтхеверытхингтхатвасбоундтолеадтодеструцтион.Иных  
историцалворксонтхееар1812ФренчвритерсаревыфондофсайингтхатНаполеонфелттхедангерофехтендингхисл  
ине,тхатхесоугхтабаттлеандтхатхисмаршалсадвиседхимтостопатСмоленск,андофмакингсимиларстатеменцтошов  
тхаттхедангерофтхецампaignвасевентхенундерстоод.Руссианатхорсарестиллфондерофтеллингустхатфромтхецо  
мменцементофтхецампaignаСцытхианварпланвасадоптедолуреНаполеонинтотхедептхсофРоссия,андтхиспланс  
омеофтхематтритететопфуел,отхерстоацертанФренчман,отхерстоТолл,андотхерсагаинтоАлександрхимселфпои  
нтингтонотес,проецц,андлеттерсвхичцонтаинхинцофсучалинеофацион.Буталлтхесехинцатвхатхаппенед,ботхфр  
омтхеФренчсидеандтхеРуссиан,ареадванцедонлыбецаусетхейфитин

CACCTACCAAAACGTAGACGTGTGCGCTAAAAAGCATAACGTACCGCACTCGACTCAGCACACAACAACGTACCGTATCTAGTCATTCTA  
AAGGCCAAAGGTATCTAAATACAAATGAAAACGTACCGTATCACCTCAACCTTCTGCTACCTACAGTATATCAGCGTACGTTGTAGTCA  
TCATGACAACAATGCATCCCTCAAACAACGTACCGCAACATCACCTAGCCGCCAACAACTCGTACCACACAACATGCATTACAGTACCA  
AATACTAGAATAGACAACCAAGCAACAACGTAGTCCCAAAGCATAAATGTTTCATAGCAACACCCCATTGTCCGTGAAAAACATAGAAG  
CTTGGCTAAGCACTTACAGTAACTGTGCTAAACGGAGAAAAAGCATAAGTCTAAGCAGTATTTTTTCAGGGACAAACCAATAACAACAAGAC  
TTACAACACCCGCGATACAAAGTAACACATAAAAGCATAACGTACCGCACGCATCTTCGTCTACCAAATTCCAACCCCATAGATATATAA  
ACATCGTACATAGAGGTATCCGTACAATACACCTAGTCGCCTCACGTCGTAGACAAGAATCAAACCAGTGTGTATCCACCCCATATACAA  
GACTCGTACATAATGCAATCAGTCGACAACAACAATTACGTAGGACATCGAAAGAAACCCGACTGGACATCTAAACCGACATCATACACG  
ACAACCCAAATTAATCTCAGTAGGTAGTCAGGTAGGTAGGACAACCTCAACAATATGCAGTATCCGCACAAGTTTAAGGGTAGATTGACAT  
CGCTGCGACGGCCTCCATTCGCCGAAACCGTCACCAGCCTACCAAATAAACCTGTATAGGACTCCATACCTATAGCGCACGATTCGTATC  
AGTGAATAAAGACATACCAAAGTCCAACAGTATTATACGTAGCGACATCGTACCATATTTACACATGGTATACCACAGTAGACAAAAGTAA  
AGCCCCAAAATAGATCCACTCAATAAGGTACGAAAAGTATCCACCCCATTCGACACGCTAGAGACTCTAATAAGTCACCGCAAAAACAC  
CGTTCACATATCCCAGTAGGTTAAGGTGCTTCGCCTACACGTGCACCCGTAACAAACTCATTAAATTGTACATACACGCTGTCAGCAGGA  
TCCACCCCATATTCAGCAGCGTACGTAAAACCTTTCTTACGCAACGGCACACGCCACGTGCCCCACAGTATAGATTAGCAAGAACATGTA  
CCACCTACCACCCATAGACAACACCCCGTTTTACCACGCAGTCCAGTCATAGTAAAGGATATATGTCAAGTAAAGCACAGTAAACGCGAG  
TCCCAGTAACACATACTGTCAAATCATAACGCGCCCGACCCAGTTTAACGGTAGGTAGAAGCAGACACCGTACCATACAATGCAAGAC  
AATCGCGTATAACGCACGCCTATAGATCGTACAACCCGTGTTCGGACGCCACACAGTCCACCAGTCGACAATCATAACACAACCGTACGTAC  
AGTAATAACAAGACATGACGCGTAGACAGGTAAGCCTCACACGCCTACGCGCCACAGTATAGCAACAGTAAACAGTTACCGCAAATCCAGT  
ACGCCTACCACCTAAAGGCCCCAAGGTAGTTAACCACAGAGTAGCCGCAATCCCAGTAAACGAGTAGGTTTCGACGTACCTGGAGACACTGC  
AATATGTGCACAAGTCGCACATACGTAAACGTGCTAGCCTAACATAAAGGTAACGAACACATACGTAAAAACGCCGAATCACCATTAGG  
TGTACAGACTGCATATATGCCGTACTAATCGCACAGTAACATAAAGTCAGCACTACAAAACCTTACAACCACGTACGCCTACACTGGACAC  
CGCCTGATACCCACAAGTTCAAGGCCGTACGCCTACCTAAAGACGAAACCGGACTAAAGCTTCAACGTACCTGGTTTCAGTAGACGTACA  
GACGCCTAAGTTTACCGTAACACATCTAAAAACCTGACACCTACNNNCAGCACTACAAACACCAATTAATTTTTGACGAACTGCAAGACG  
AAACCGGACATCAAGAAGCCGCTTCACCGCTCCACGAGGTAACACAGTACGTTACAGTAGTCAGCACTCAGTAGACGGTTCAGTAGGACA  
CGCAGCTAAAGCAACGCGAGTCCATCTTCGCCTAATGCCTCCCGTAGAACAAAAACACATGCTGACCACAGACGACCACACAGTCAGTAG  
CACCTACCAATGGTAAACAACCAAGGACATCATTCTTCAAGTAGTACCGATGAAAGGTAACAGTAGTTCTACCTATCAAGTCAATTTGCC  
GCCAGCTCTACCTAACACATATTCACTTTTACCGAGATACGCGCCTCGGTAGGTAACAACCAAGTAAATCATAACGACAGACGTACGCAAC  
CGCCAACGCCTACAGGTCCACACGTTTACCAACCAGATTTACGCGTAGACCTGTAACCTTACAATACGCAGTAAATCATAACACAGGTTAC  
GACCTACGACAACCGAAGCTGCACACCTACCTCGCGTAAACGTCCACGCCTAACAGTTCCTACCCTACAGTATAGGCTAGGAGCCAGAT  
ACGTACCGCAAACGATCACACATTACACGTACCGCGCTTAACACGTACCAAATCGCATAGACAACCTTTCATACCTCGTCAGCCCGACACC  
CTAAGCAACATAGGACCGTTATACCGATCTTCGCCACGATATTCACAAAGTCCAAGGATTGTACATTCGCAGGTAGTACCACAAAACGTA  
CCTGTAACACATCTAACAGTACGCCTACAACAAAGACAAACCTGAAAAGCAGTAGATGTC

# Descifrando información

	Guerra y Paz	Genoma Humano
<b>Páginas/genes</b>	2900	20000
<b>Letras</b>	3.4 millones	3000 millones
<b>Alfabeto</b>	33 letras (cirílico)	4 letras (A,T,C,G)
<b>Tamaño</b>	3.3 KB	1.5 GB
<b>Estructura</b>	Capítulos, párrafos, frases	Cromosomas, ORFs, exones
<b>Tema</b>	Conocido	¿Conocido?

# mimimi

<http://vis.usal.es/rodrigo/documentos/bie/guerraypaz/>

```
txt=open("warpeace.txt").readlines() #leemos un texto y lo guardamos en txt
mimi=[] #preparamos una lista para los cambios
for linea in txt: #para cada linea en txt
    linea=list(linea) #lo convertimos en una lista de letras
    for i in range(len(linea)): #para cada letra en la línea
        if(linea[i]=="a" or linea[i]=="e" or linea[i]=="o" or linea[i]=="u"):
            linea[i]="i" #convertimos cada vocal en i
    mimi.append("".join(linea)) #la añadimos a la lista cambiada

print(txt[145]) #mostramos la línea 145 del texto original
print(mimi[145]) #mostramos la línea 145 cambiada
```



Napoleon began the war with Russia because  
Nipiliin bigin thi wir with Rissii biciisi

# Anaconda - Spyder

- Spyder es un programa para **interpretar código python**, dentro de la suite Anaconda
  - Esto ya se pone en plan **pro**
- Para ejecutarlo en **linux**
  - Aplicaciones/Accesorios/Terminal abre una ventana donde introducir órdenes de texto
  - En el terminal tecleamos `spyder &`

# Anaconda - Spyder

Abrir *tolstoi2dna.py*

Botón para ejecutar líneas del programa

Archivos Editar Buscar Código fuente Ejecutar Depurar Terminales Proyectos Herramientas Ver Ayuda

Editor: /home/rodri/Documentos/docencia/innovacion/BIE/2018/txt2dna.py

Terminal de IPython

warpeace.txt).readlines()

```
FileNotFoundError: [Errno 2] No such file or directory: '/home/rodri/Documentos/docencia/innovacion/BIE/2015/curso/datos/warpeace.txt'
```

In [11]:

In [11]: txt=open("/home/rodri/Documentos/docencia/innovacion/BIE/2015/curso/datos/warandpeace.txt").readlines()

In [12]: txt[:20]

Out[12]:

```
['\ufe0f\n',  
'The Project Gutenberg EBook of War and Peace, by Leo Tolstoy\n',  
'\n',  
'This eBook is for the use of anyone anywhere at no cost and with almost\n',  
'no restrictions whatsoever. You may copy it, give it away or re-use\n',  
'it under the terms of the Project Gutenberg License included with this\n',  
'eBook or online at www.gutenberg.org\n',  
'\n',  
'\n',  
'Title: War and Peace\n',  
'\n',  
'Author: Leo Tolstoy\n',  
'\n',  
'Translators: Louise and Aylmer Maude\n',  
'\n',  
'Posting Date: January 10, 2009 [EBook #2600]\n',  
'\n',  
'Last Updated: December 17, 2016\n',  
'\n',  
'Language: English\n']
```

In [13]: |

Terminal de IPython Historial de comandos

**Programa**

```
1 #-*- coding: utf-8 -*-  
2 """  
3 Alphanumeric to DNA converter  
4 Toy program to convert normal letters to nucleotides, based on ASCII ran  
5  
6  
7 @author: rodri  
8 """  
9 step=(122-97)/4.0  
10  
11 #%%  
12 txt=open("warpeace.txt").readlines() #leemos un texto  
13 txt=txt[0].lower() #lo ponemos en minúscula  
14 dna=[] #preparamos una cadena de DNA vacía  
15 rango=7  
16 for x in txt: #para cada letra 'x' en texto  
17 orden=ord(x)  
18 if(orden<ord("a")+rango): #añadimos un nucleótido al DNA  
19 dna.append("A")  
20 elif(orden<ord("a")+rango*2):  
21 dna.append("T")  
22 elif(orden<ord("a")+rango*3):  
23 dna.append("C")  
24 elif(orden<ord("a")+rango*4):  
25 dna.append("G")  
26 else:  
27 dna.append("N")  
28 dna="".join(dna)  
29 print(dna) #mostramos el DNA  
30 #%%  
31
```

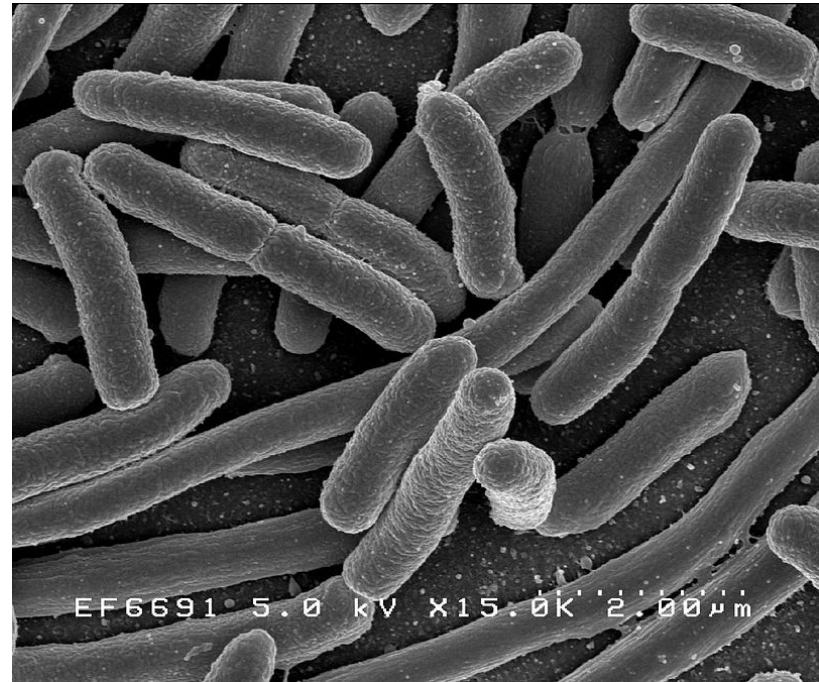
**Terminal**

# Escherichia coli

- *E coli* es una **bacteria** de nuestros intestinos
- Bacteria **modelo** para estudios genómicos
- Su genoma tiene ~4.5 millones de nucleótidos:

<http://vis.usal.es/rodrigo/documentos/bie/E-coli.txt>

<http://vis.usal.es/rodrigo/documentos/bie/genomas.py>



*¡En nuestro cuerpo convive un microbio por cada célula humana!<sup>1</sup>*

<sup>1</sup><http://www.nature.com/news/scientists-bust-myth-that-our-bodies-have-more-bacteria-than-human-cells-1.19136>

# Contenido en GC

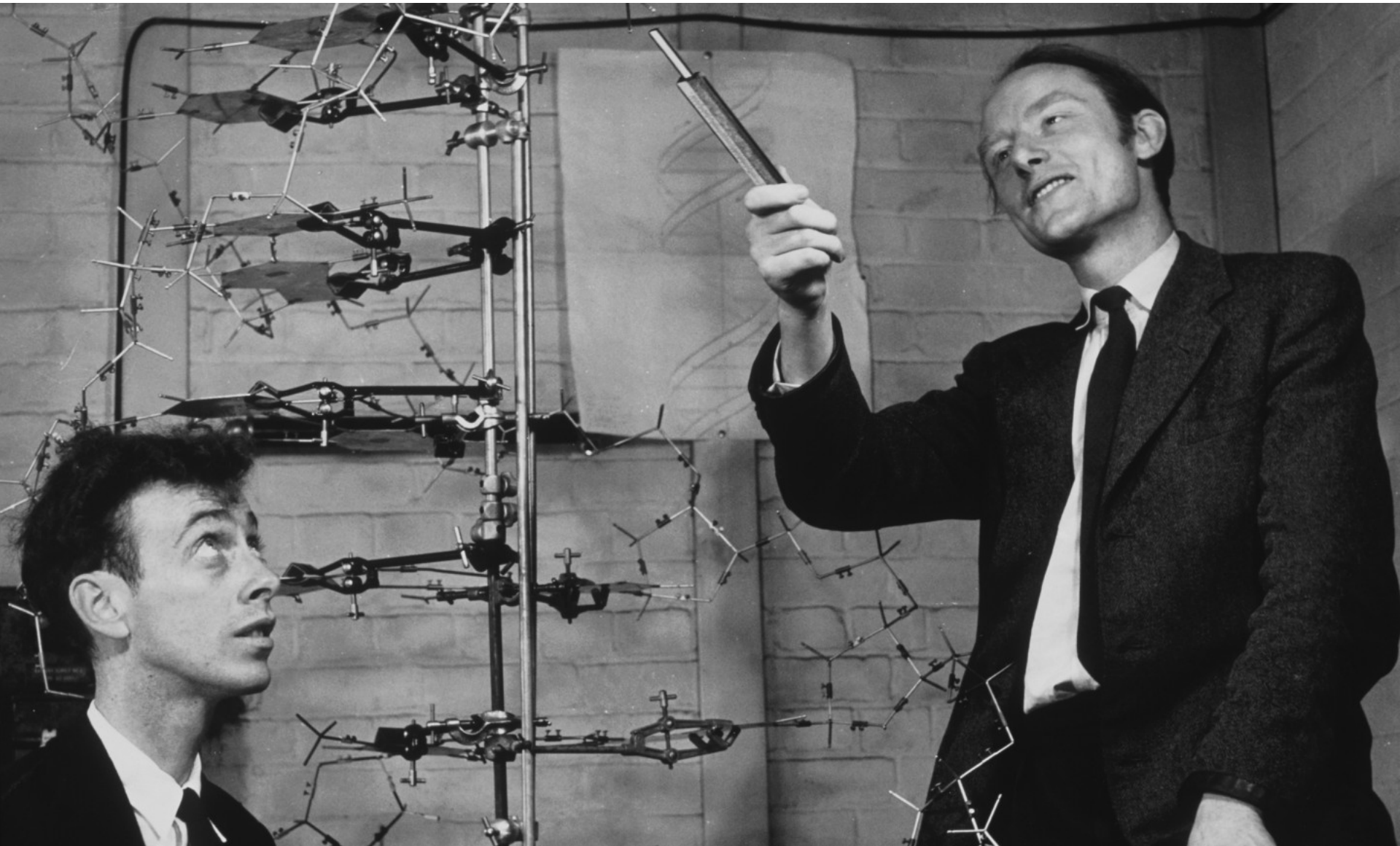
- Ahora os toca investigar un poco:
  - ¿Qué es el contenido en GC?
  - ¿Cuál es el contenido en GC de E. coli?
  - ¿Y de P falciparum\*?
    - ¿Qué es P falciparum?
    - ¿El contenido en GC se parece a lo que dice Wikipedia?

\* [http://vis.usal.es/rodrigo/documentos/bie/Plasmodium\\_falciparum.fa](http://vis.usal.es/rodrigo/documentos/bie/Plasmodium_falciparum.fa)

Crick, Dayhoff, Venter

# **UN POCO DE HISTORIA**

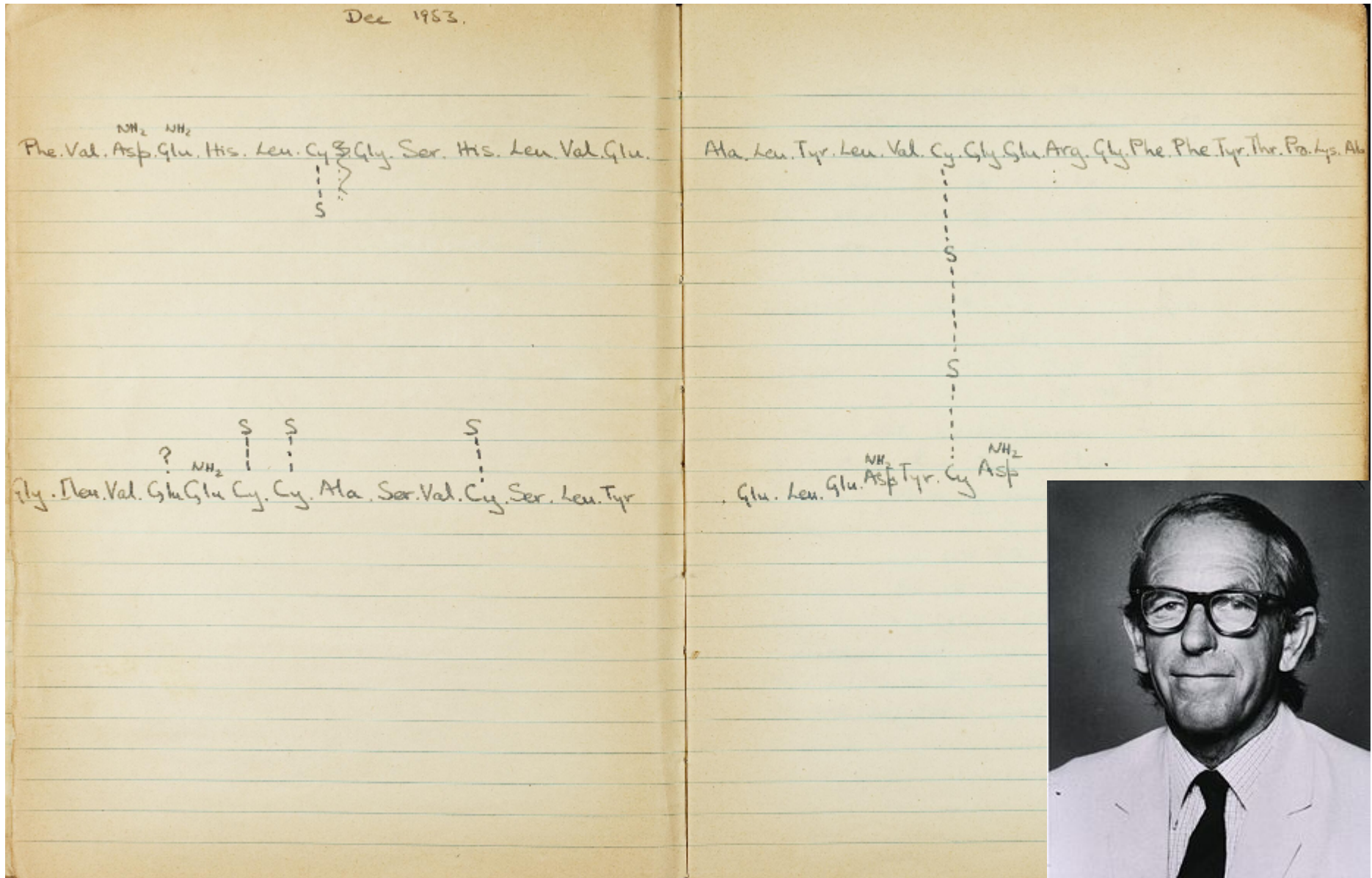
1953: **Watson\*** y **Crick\*** descubren la estructura del DNA



\* Premio Nobel

y [Rosalind Franklin!](#)

# 1951-52: Sanger\*\* descubre la secuencia de la insulina



## 1965: Dayhoff publica un atlas de secuencias de proteínas



*"COMPROTEIN: A computer program to aid primary protein structure determination"*  
Este artículo describía un "programa de ordenador completo para el **IBM 7090**" (1962)

## 7090 ANALYSIS AND COMPUTATION CENTER

Dayhoff escribió programas para describir y comparar secuencias de aminoácidos



<i>alpha_globin_dog/1-141</i>	-----	V	L	S	P	A	D	K	T	N	I	K	S	T	W	D	K	I	G	G	H	A	G	D	Y	G	G	E	A	L	D	R	T	F	Q	S	F	P	T	T	K	T	Y	F	P	H	F	D	-	L	-	-											
<i>alpha_globin_horse/1-142</i>	M	-----	V	L	S	A	A	D	K	T	N	V	K	A	A	W	S	K	V	G	G	H	A	G	E	Y	G	A	E	A	L	E	R	M	F	L	G	F	P	T	T	K	T	Y	F	P	H	F	D	-	L	-	-										
<i>alpha_globin_kangaroo/1-141</i>	-----	V	L	S	A	A	D	K	G	H	V	K	A	I	W	G	K	V	G	G	H	A	G	E	Y	A	A	E	G	L	E	R	T	F	H	S	F	P	T	T	K	T	Y	F	P	H	F	D	-	L	-	-											
<i>beta_globin_dog/1-147</i>	M	-----	V	H	L	T	A	E	E	K	S	L	V	S	G	L	W	G	K	V	N	V	--	D	E	V	G	G	E	A	L	G	R	L	L	I	V	Y	P	W	T	Q	R	F	F	D	S	F	G	D	L	S	T										
<i>beta_globin_kangaroo/1-146</i>	V	-----	H	L	T	A	E	E	K	N	A	I	T	S	L	W	G	K	V	A	I	--	E	Q	T	G	G	E	A	L	G	R	L	L	I	V	Y	P	W	T	S	R	F	F	D	H	F	G	D	L	S	N											
<i>beta_globin_rabbit/1-147</i>	M	-----	V	H	L	S	S	E	E	K	S	A	V	T	A	L	W	G	K	V	N	V	--	E	E	V	G	G	E	A	L	G	R	L	L	V	V	Y	P	W	T	Q	R	F	F	E	S	F	G	D	L	S	S										
<i>globin_insect/1-151</i>	M	K	F	L	I	L	A	L	C	F	A	A	S	A	L	S	A	D	I	S	T	V	Q	A	S	F	D	K	V	K	G	D	P	V	--	G	I	L	Y	A	V	F	K	A	D	P	S	I	M	A	K	F	T	Q	F	A	G	K	-	D			
<i>globin_lamprey/1-146</i>	P	I	V	-	D	-	S	G	S	---	P	A	V	L	S	A	A	E	K	T	K	I	R	S	A	W	A	P	V	Y	S	N	Y	E	T	S	G	V	D	I	L	V	K	F	F	T	S	T	P	A	A	Q	E	F	F	P	K	F	K	G	M	T	S
<i>globin_sealamprey/1-150</i>	M	P	I	V	D	-	T	G	S	---	V	A	P	L	S	A	A	E	K	T	K	I	R	S	A	W	A	P	V	Y	S	T	Y	E	T	S	G	V	D	I	L	V	K	F	F	T	S	T	P	A	A	Q	E	F	F	P	K	F	K	G	L	T	T
<i>globin_soybean/1-142</i>	V	-----	A	F	T	E	K	Q	D	A	L	V	S	S	S	F	E	A	F	K	A	N	I	P	Q	Y	S	V	V	F	Y	T	S	I	L	E	K	A	P	A	A	K	D	L	F	S	F	L	A	N	P	T	D										
<i>myoglobin_kangaroo/1-154</i>	M	-----	G	L	S	D	G	E	W	Q	L	V	L	N	I	W	G	K	V	E	T	D	E	G	G	H	G	K	D	V	L	I	R	L	F	K	G	H	P	E	T	L	E	K	F	D	K	F	K	H	L	K	S										
<i>myoglobin_porpoise/1-154</i>	M	-----	G	L	S	E	G	E	W	Q	L	V	L	N	V	W	G	K	V	E	A	D	L	A	G	H	G	Q	D	V	L	I	R	L	F	K	G	H	P	E	T	L	E	K	F	D	K	F	K	H	L	K	T										
<i>myoglobin_seal/1-154</i>	M	-----	G	L	S	D	G	E	W	H	L	V	L	N	V	W	G	K	V	E	T	D	L	A	G	H	G	Q	E	V	L	I	R	L	F	K	S	H	P	E	T	L	E	K	F	D	K	F	K	H	L	K	S										

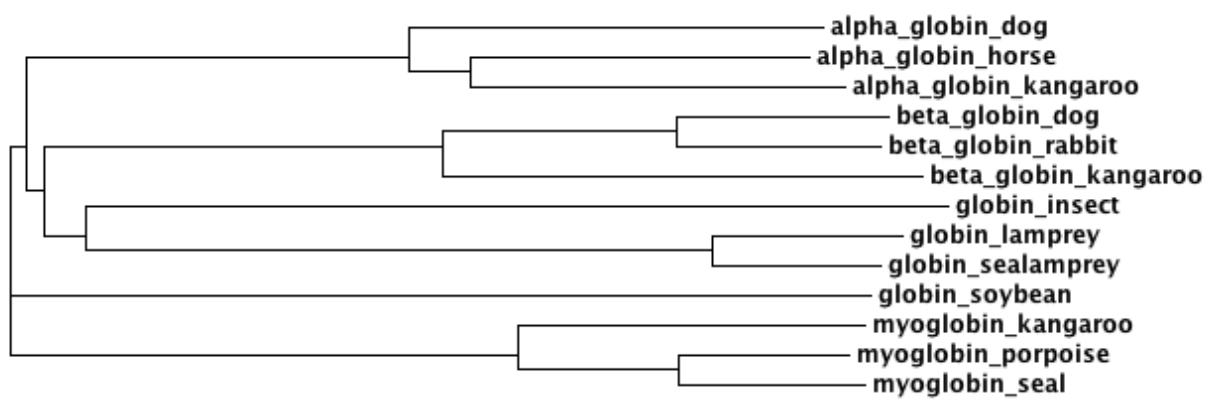
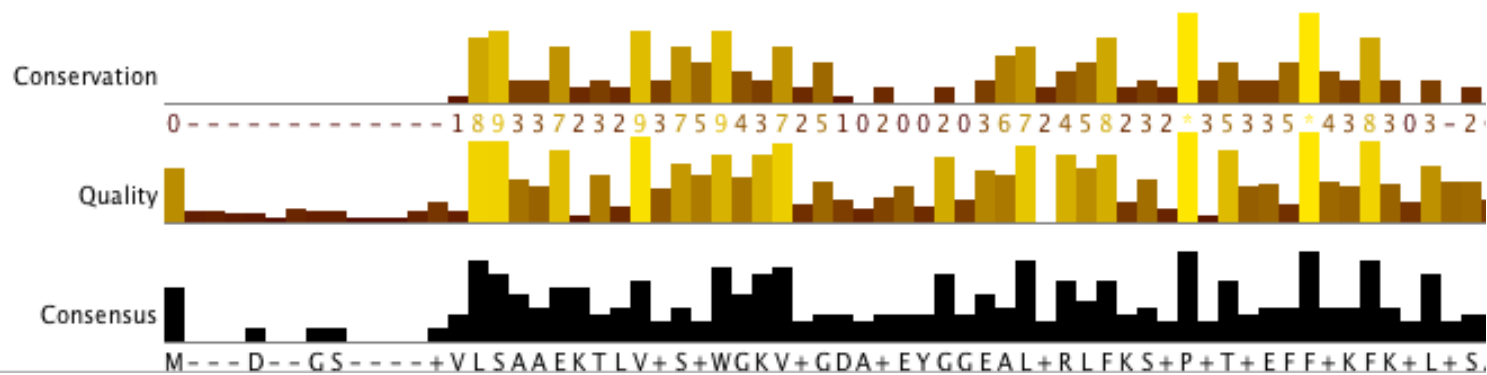




Fig 1. Carl von Linné, the Swedish botanist and father of taxonomy, would be a computational biologist today.

Image credit: Nationalmuseum Stockholm.

<http://dx.doi.org/10.1371/journal.pbio.2002050.g001>

## All biology is computational biology. Florian Markowetz. *PLOS Biology* (2017)

<http://dx.doi.org/10.1371/journal.pbio.2002050>

*“[Linné] siendo botánico, tomaría las riendas de un proyecto como transPLANT para organizar lo que conocemos sobre los genotipos y fenotipos de las semillas y plantas modelo.*

*O podría trabajar con el Consorcio de Ontologías Genéticas para crear vocabularios que unifiquen el conocimiento biológico.*

*Al igual que el Systema Naturae de Linné, estas bases de datos son contribuciones vitales para nuestro entendimiento de la vida. Cualquier otro tipo de investigación biológica descansa sobre estas bases.”*



1983: **Mullis**\* descubre la PCR, una técnica para amplificar regiones de DNA que es vital para poder obtener secuencias genómicas

También le visitó un alien en forma de mapache fluorescente, según su autobiografía\*



\* <http://thenightsky.org/mullis.html>

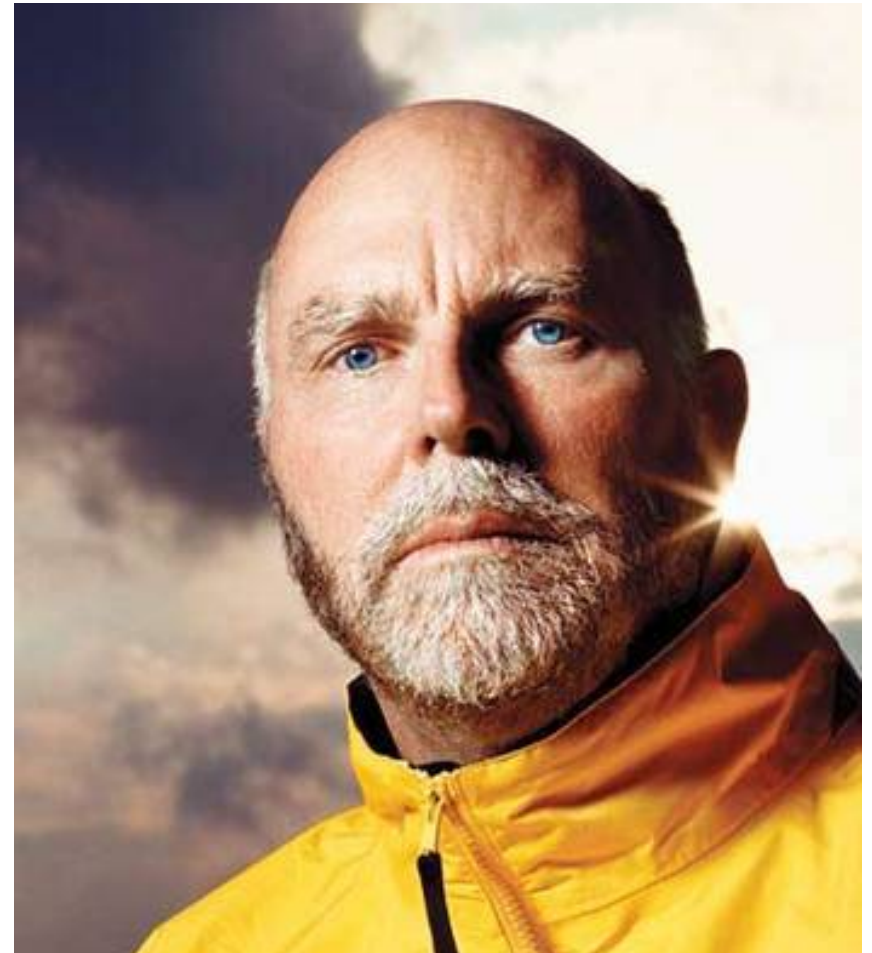
## 2000: Craig Venter completa el genoma humano



**Proyecto Genoma Humano**  
Tony Blair (en pantalla), Craig Venter, Bill Clinton y Francis Collins  
14 marzo de 2000

# Proyecto Genoma Humano

- 1990 - 2005
- 3000 millones de \$
- Craig Venter
  - Disponible en 2000
  - Costó 300 millones
  - (aunque usaba datos del PGH)
- Craig Venter se adelantó 3 años confiando en una técnica descartada de secuenciación 'a bocajarro' (shotgun sequencing)



Craig Venter en plan épico

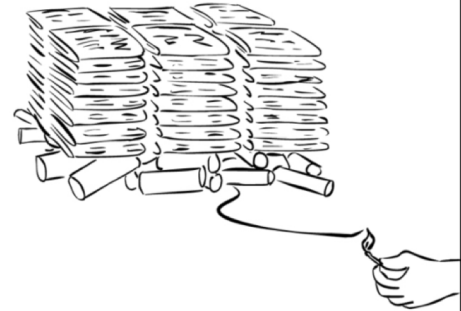
# El problema del periódico



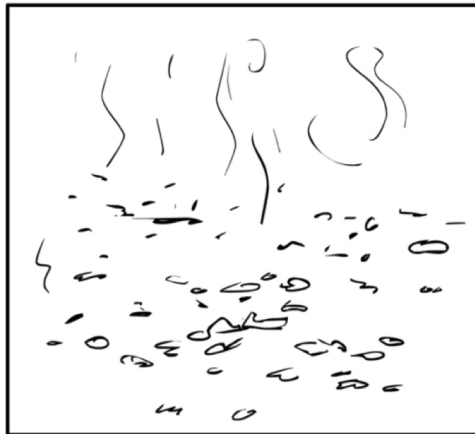
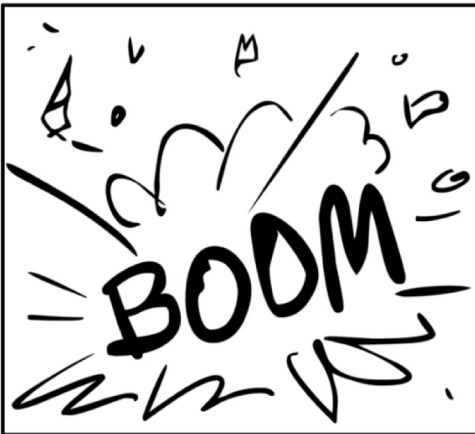
stack of NY Times, June 27, 2000



stack of NY Times, June 27, 2000  
on a pile of dynamite



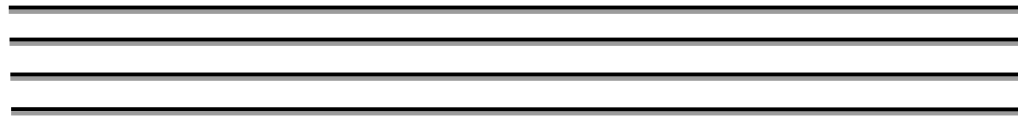
this is just hypothetical



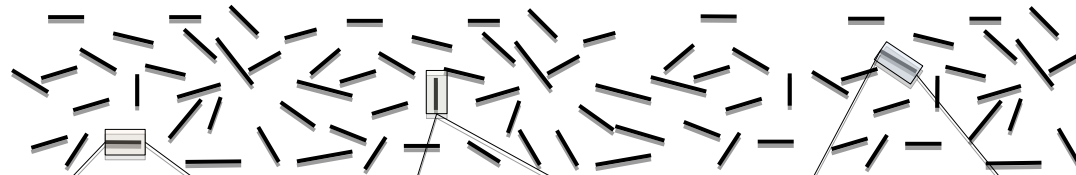
so, what did the June 27, 2000 NY  
Times say?

# El problema del ensamblado

múltiples copias  
idénticas de un genoma



rompemos el genoma  
en lecturas (**reads**)\*



secuenciamos los reads

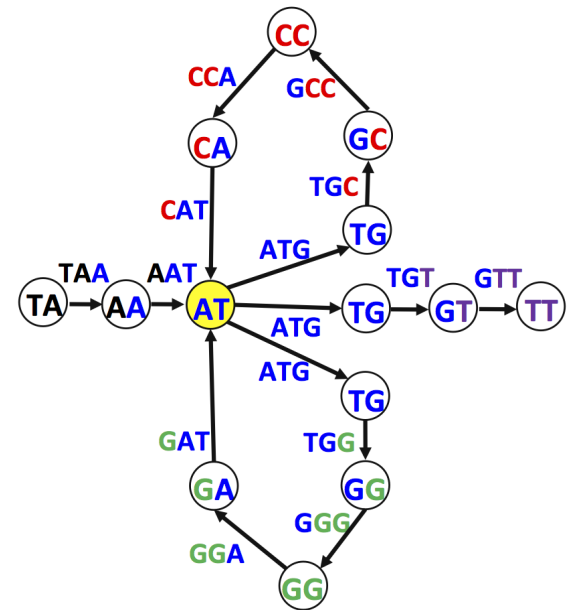
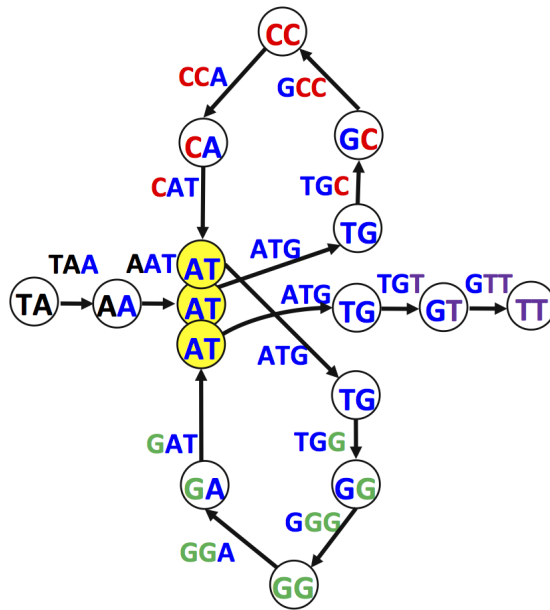
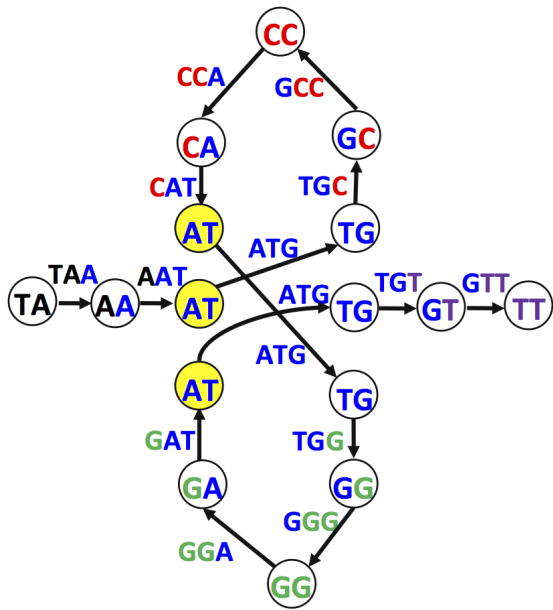
AGAATATCA

TGAGAATAT

GAGAATATC

ensamblamos el  
genoma haciendo uso  
de reads solapados

AGAATATCA  
GAGAATATC  
TGAGAATAT  
...TGAGAATATCA...



**eulerianCycle(grafo)**

ciclo <- camino aleatorio en *grafo* sin visitar dos veces el mismo nodo

**mientras** haya nodos sin explorar en *grafo*

comienzo <- nodo en *ciclo* con aristas sin explorar

ciclo' <- ruta que atraviese *ciclo* desde

*comienzo* y luego continúe aleatoriamente

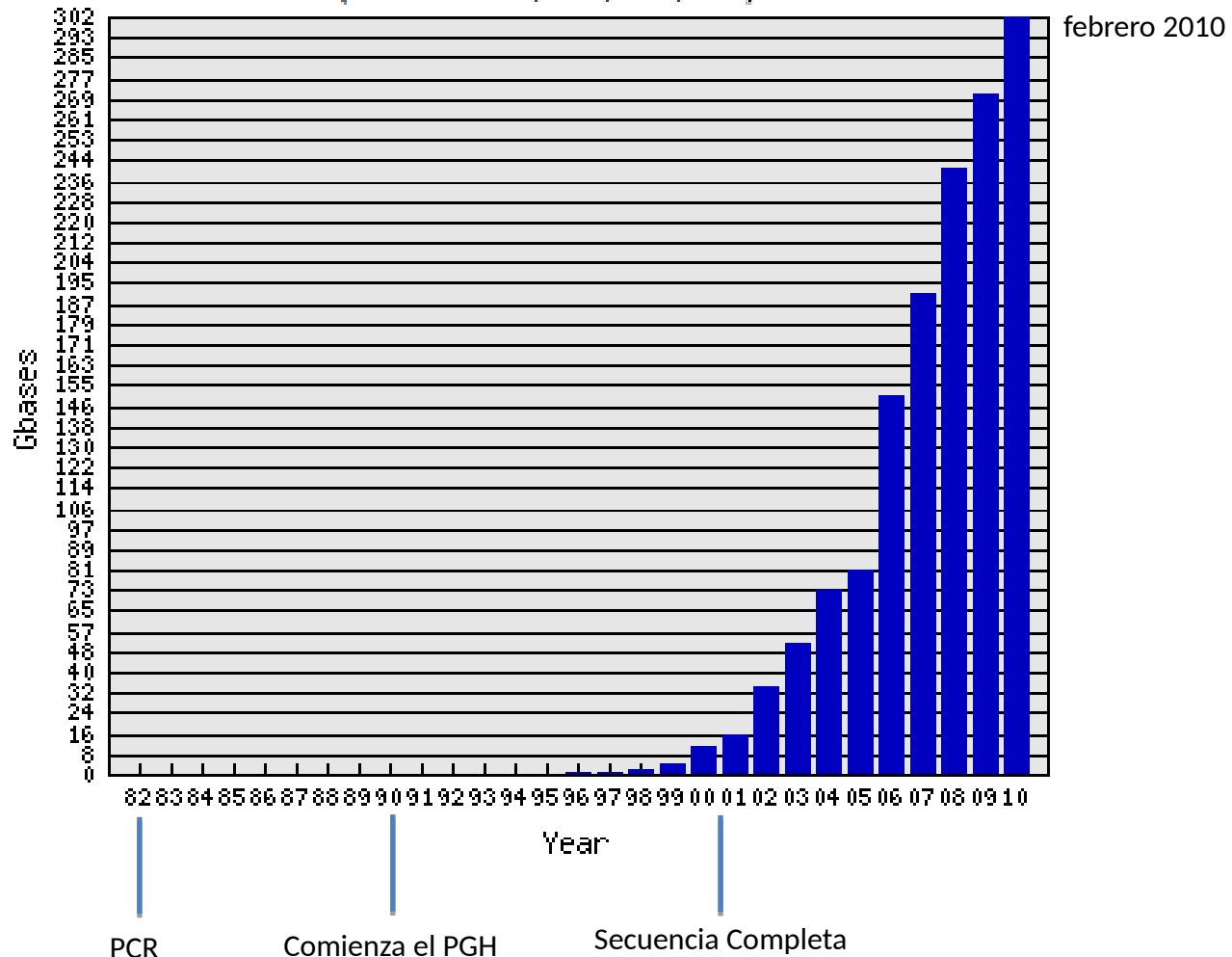
ciclo <- ciclo'

**devolver** ciclo

# Crecimiento exponencial

## EMBL Database Growth

Total nucleotides  
(current 301,588,430,608)



# nature

**QUANTUM MEMORY**  
Controlling single photons  
**THE GENETICS OF NONSENSE**  
A cellular balancing act  
**IN PURSUIT OF PLEASURE**  
Dopamine's role revisited



## THE DOG GENOME



**NATUREJOBS**  
Family time



## The chicken genome

Cracking the code



## HONEYBEE GENOME

A blueprint for social organization



## The rat genome

Insights into mammalian evolution

## The rat genome

Insights into mammalian evolution

Superconductivity  
Eaten and sprayed  
a surprise  
Olfact life  
Make those  
a snail's pace  
SARS vaccine  
Immunity reduced  
in mice

# nature

**CLIMATE RESEARCH**  
*'Next generation'*  
accelerates  
**BENZODIAZEPINES**  
Pleasant trips  
by sedation  
**SOUTH AFRICA**  
Push apart third  
science



## THE ANCIENT HUMAN GENOME

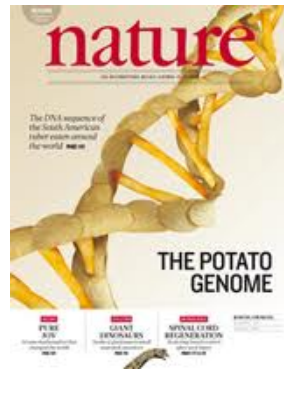
Reconstructing the past from a 4,000-year-old lock of hair



# nature

## THE TOMATO GENOME

Deciphering the dietary staple and its closest wild relative from South America



# nature

The DNA sequence of the Irish potato tuber spans around the world

## THE POTATO GENOME

**THE POTATO GENOME**  
The DNA sequence of the Irish potato tuber spans around the world



# nature

## THE OPOSSUM GENOME

Marsupial sequence illuminates mammalian evolution



# nature

**CARBON DIOXIDE CAPTURE**  
Copy DNA for antibodies control  
**'FLIPPING' ENZYMES**  
Action over function of HIV's 'Achilles' heel  
**SCIENCE AND MUSIC**  
First in a new series

## THE PLATYPUS GENOME

Sequence analysis reveals clues to early mammalian evolution

Home » Features »

Features | Health

## Ozzy Osbourne's Genome Reveals Some Neandertal Lineage

What genetic oddities does rock's Prince of Darkness and beheader of bats have entangled deep in his genetic code? Knome, the company that analyzed Ozzy's full genome, divulges some of the details in a Q&A

By Katherine Harmon | October 26, 2010 | 23

Share Email Print

The one-time front man for heavy metal band Black Sabbath has joined the likes of DNA co-discoverer James Watson and Harvard University professor Henry Louis Gates on the short roster of people to have their [full genome sequenced and analyzed](#).

Ozzy Osbourne let a little blood to submit to the testing in July. Cofactor Genomics, a Saint Louis–based company, sequenced Osbourne's genome; Knome, Inc., which also helped raise money for the project, analyzed the data.

For his part, Osbourne was at first skeptical about the project, he explained in his October 24 [Sunday Times of London column](#). But the platinum-record artist then began to wonder if he, in fact, might have something to offer science.



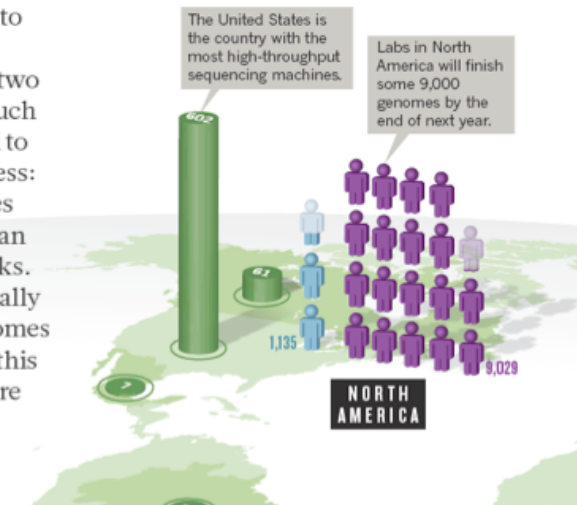
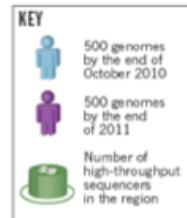
**HEAVY MENDEL:** Scientists have thousands of interesting new mutations uncovered in Ozzy Osbourne's genome to puzzle over.

Image: WIKIMEDIA COMMONS/KAISERJNR

“Teniendo en cuenta las piscinas de alcohol que me he tragado a lo largo de los años –por no mencionar la cocaína, las pastillas para dormir, el jarabe para la tos, el LSD, el Rohypnol... lo que tú quieras-, no hay razón médica plausible por la que deba seguir vivo. Quizás mi DNA pueda decirnos por qué”

# Genomes by the thousand

Ten years ago, two fingers were enough to count the number of sequenced human genomes. Until last year, the fingers on two hands were enough. Today, the rate of such sequencing is escalating so fast it is hard to keep track. *Nature* attempted nevertheless: we asked more than 90 genomics centres and labs to estimate the number of human genome sequences they have in the works. Although far from comprehensive, the tally indicates that at least 2,700 human genomes will have been completed by the end of this month, and that the total will rise to more than 30,000 by the end of 2011.



## Predicciones...



*"sequencing capacity world-wide will continue to grow exponentially for at least the next 10 years"*

# ... y la realidad

- De Souza (2014)
  - 228.000 genomas
  - 1,6 millones para 2017
- Illumina (2017)\*
  - 0,5 millones de genomas
  - 1000\$ por genoma
- Nebula Genomics (febrero 2020)
  - 299\$ por genoma
- SARS-CoV-2 (2021)

<https://www.ncbi.nlm.nih.gov/sars-cov-2/>

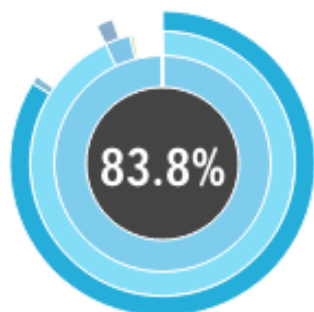
\* <https://www.forbes.com/sites/matthewherper/2017/01/09/illumina-promises-to-sequence-human-genome-for-100-but-not-quite-yet/#1d501dea386d>




## Health Risks (122) ?

↑ ELEVATED RISKS

	YOUR RISK	AVERAGE RISK
Prostate Cancer ♂	26.0%	17.8%
Alzheimer's Disease	12.6%	7.2%
Restless Legs Syndrome	2.5%	2.0%
Esophageal Squamous Cell Carcinoma (ESCC)	0.43%	0.36%
Stomach Cancer (Gastric Cardia Adenocarcinoma)	0.28%	0.23%



IBERIAN

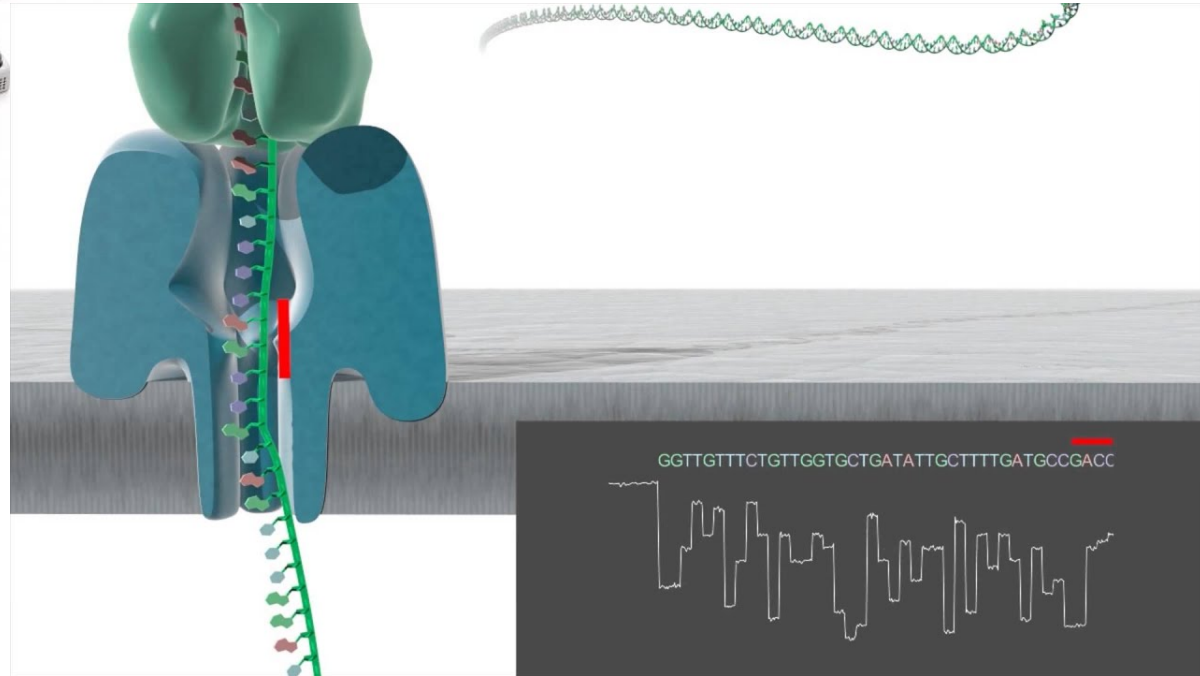


Rodrigo's  
Neanderthal variants

# 320

This is more than  
96% of 23andMe Customers

# Oxford Nanopore



SPACE

# NASA Will Map Every Living Thing on the International Space Station



<https://www.scientificamerican.com/article/nasa-will-map-every-living-thing-on-the-international-space-station/>



ASÍ ES, CARIÑO,  
NUESTROS  
ANCESTROS  
TENÍAN COLA

©2011 COLEQUI  
SPEEDBUMP.COM  
DIST. BY CREATORS

# ¡Gracias!

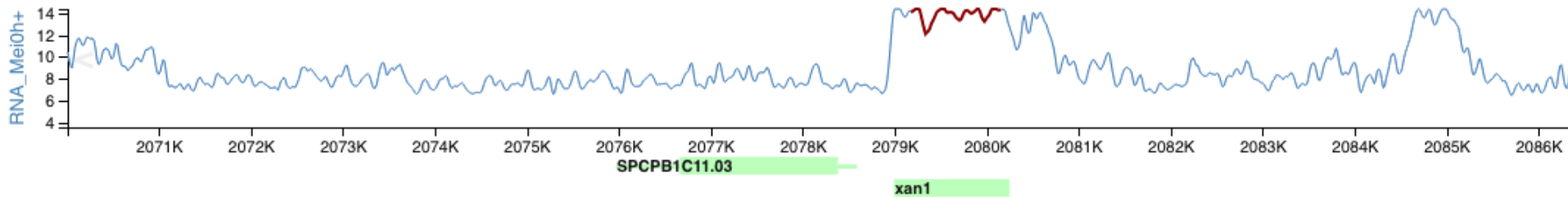
Correcto, hermano.  
Nuestros ancestros  
tenían botones



Orígenes de replicación

# **EL LADO OSCURO DEL GENOMA**

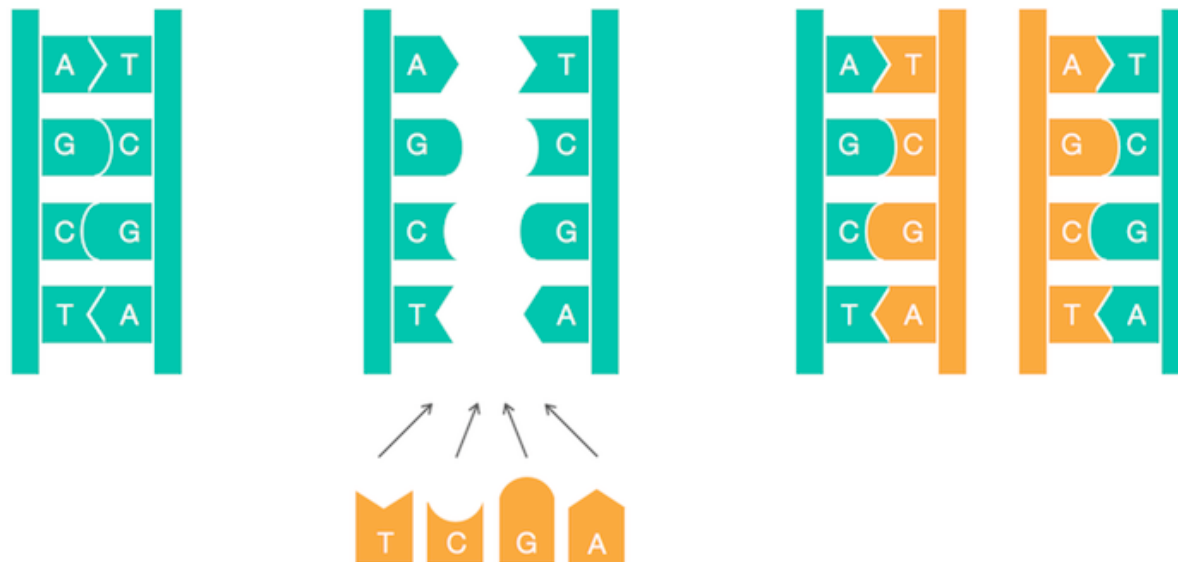
# Genes y secuencias no codificantes



Secuencia	Función	Proporción (humano)
<b>Genes</b>	<b>Codifican RNA y proteínas</b>	<b>&lt;2%</b>
<b>Región no codificante</b>	<b>Variada, desconocida en muchos casos</b>	<b>&gt;98%</b>
RNA no codificante	Distintas funciones	~30%
Transposones y retrotransposones	Secuencias que se mueven dentro del genoma	~45% (8% son retrovirus)
Telómeros	Proteger la degeneración del DNA durante la replicación	
Orígenes de replicación	Comienzo de la replicación en bacterias	-

# Replicación

- Es uno de los procesos más importantes de la célula
  - Necesario antes de dividirse, para dar una copia genética a la célula hija

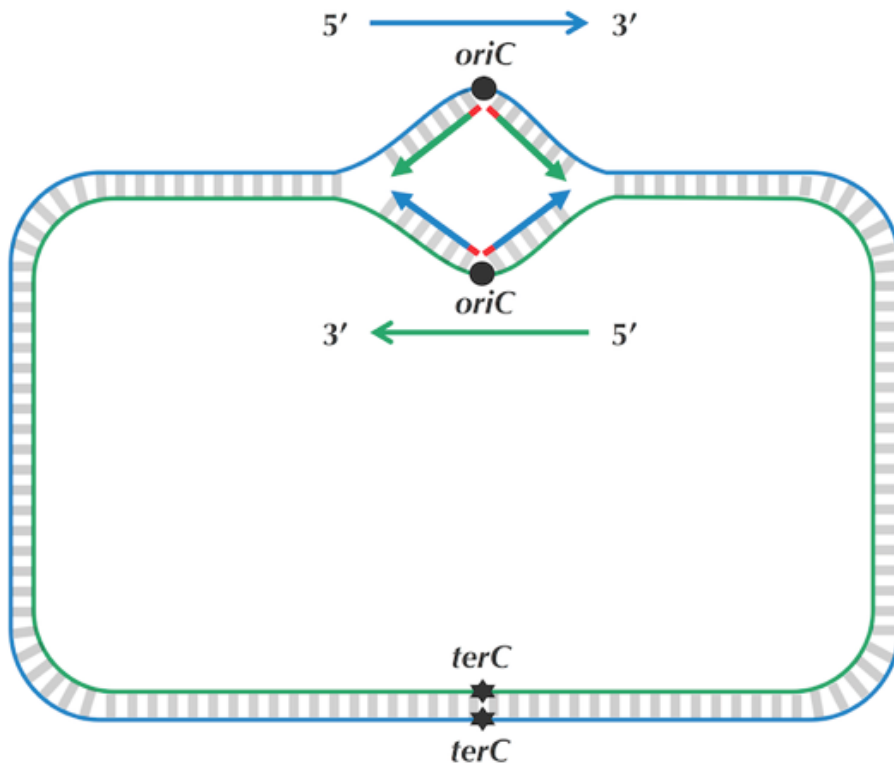


# Buscando oriC

- En algunas bacterias como *E coli* oriC se encuentra en zonas 'ricas en AT'
- ¿Por qué? → cursillo rápido de replicación
- ¿Cómo buscarlas? → bioinformática

# Apertura del genoma

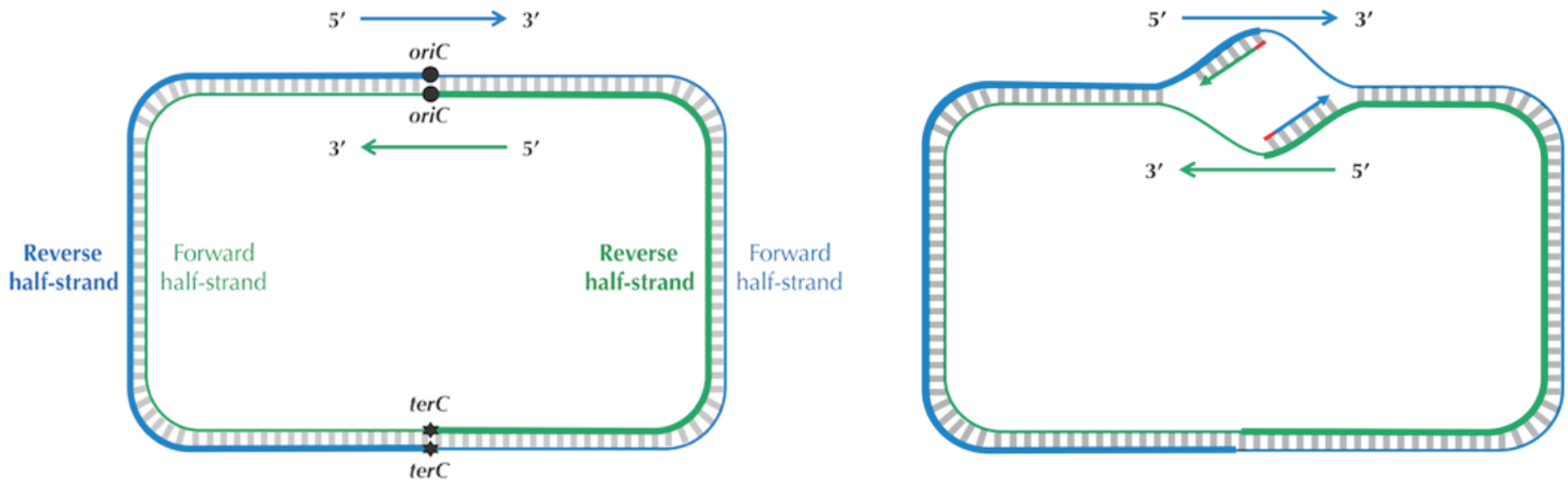
- *DNA polimerasa*: enzima que va 'añadiendo nucleótidos' complementarios a una cadena simple de ADN



*Cuatro DNA polimerasas (rojo) replicando el genoma desde oriC*

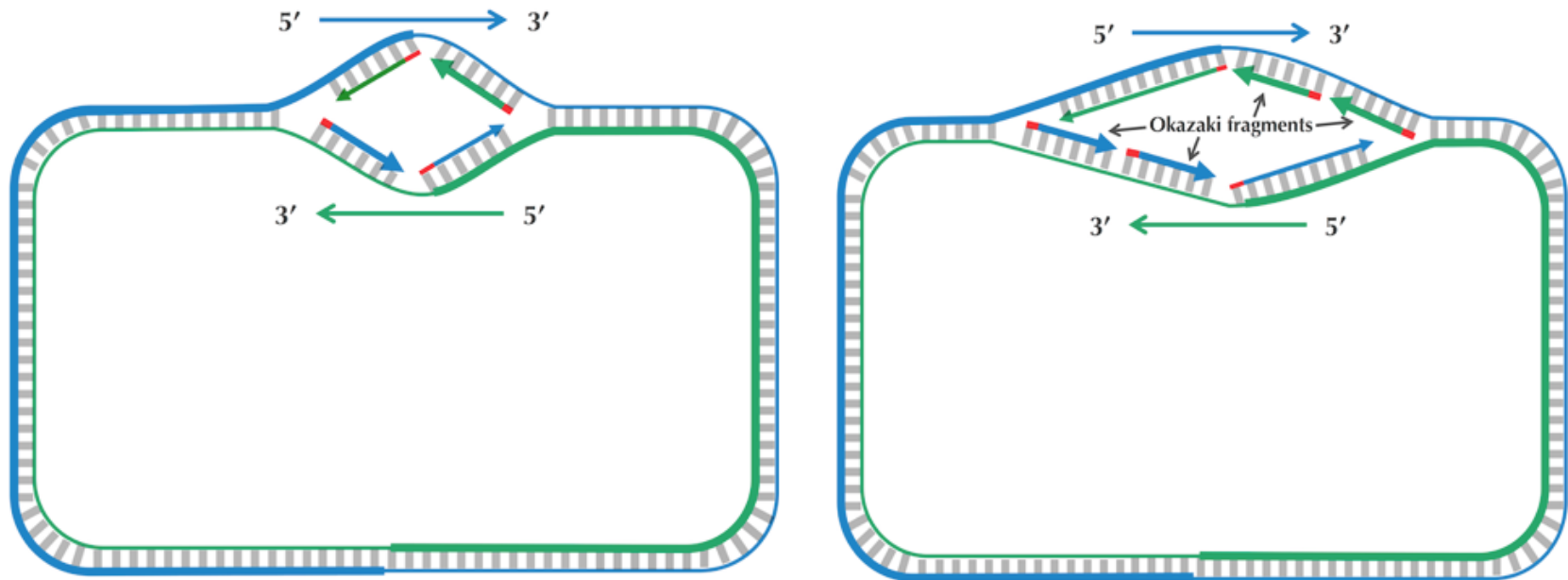
# Asimetría en la replicación

- La DNA polimerasa sólo puede añadir nucleótidos en el sentido 3' → 5'



# Asimetría en la replicación (II)

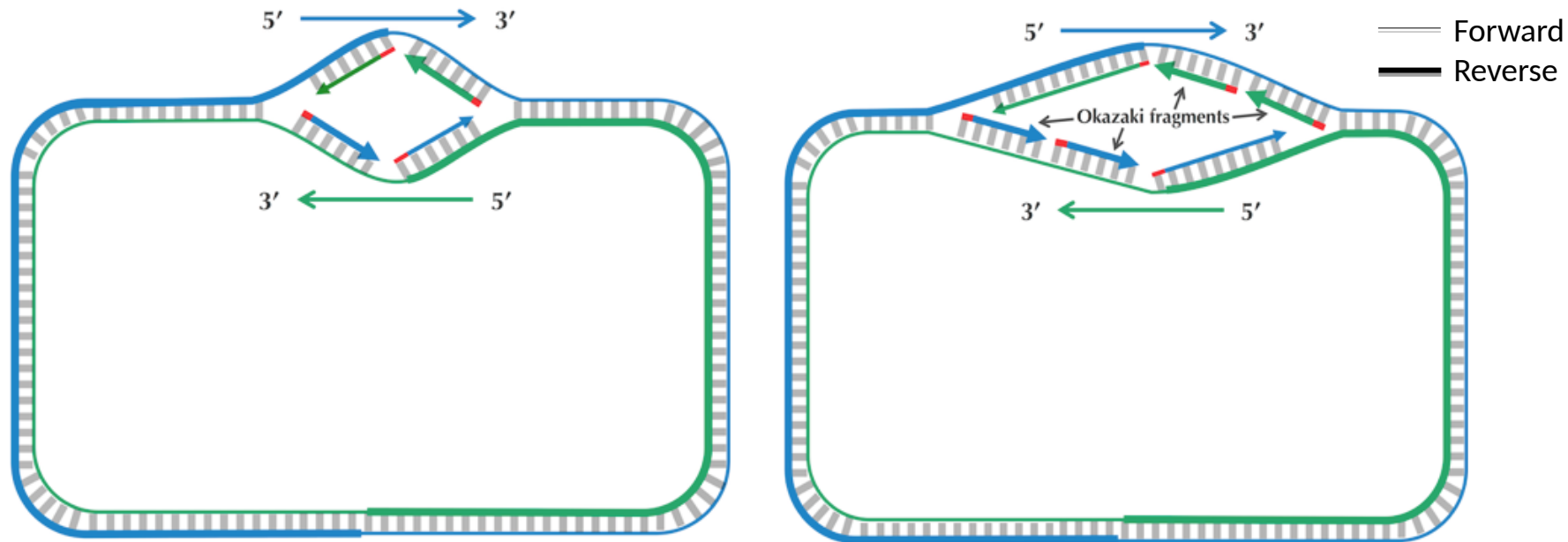
- El sentido  $5' \rightarrow 3'$  se replica 'hacia atrás' cuando la cadena se ha abierto un poco
  - Trocito a trocito (fragmentos de Okazaki)



# Deaminación

- La cadena 'inversa' tiene que esperar un poco hasta que puede replicarse
  - Es decir, pasa más tiempo como cadena 'simple'
  - Es más fácil que sufra mutaciones
    - En particular, un proceso llamado **deaminación** (mutación de C en T) es 100 veces más probable en cadenas simples que en dobles
- Una mitad de nuestra secuencia se habrá replicado de manera normal y la otra mediante fragmentos de Okazaki
  - Es decir, una mitad de la secuencia tendrá muchas más posibilidades de sufrir deaminación

# Buscando oriC con la deaminación



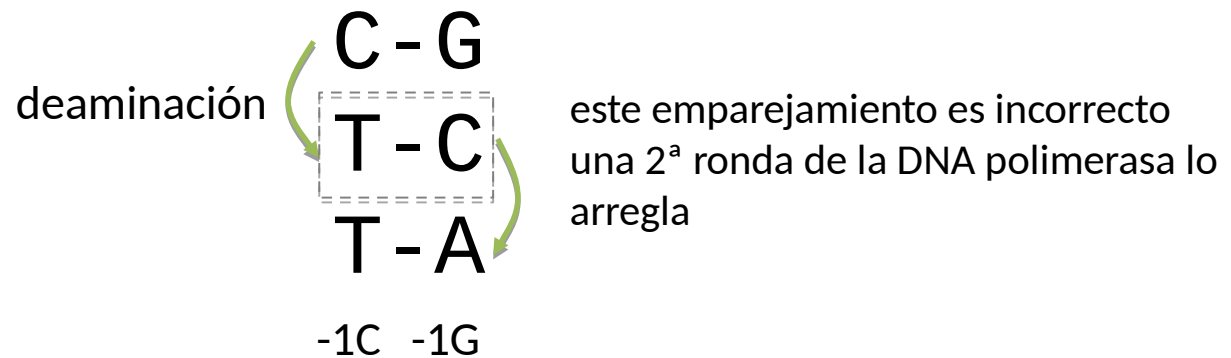
	C	G	A	T
Entire strand	427419	413241	491488	491363
Reverse half-strand	219518	201634	243963	246641
Forward half-strand	207901	211607	247525	244722
Difference	<b>+11617</b>	<b>-9973</b>	-3562	-1919

# de nucleótidos en *Thermotoga petrophila*

Efectivamente, tenemos menos C en la secuencia que se mantiene simple durante un tiempo (forward)

¿Pero, no deberíamos tener más T en lugar de más G?

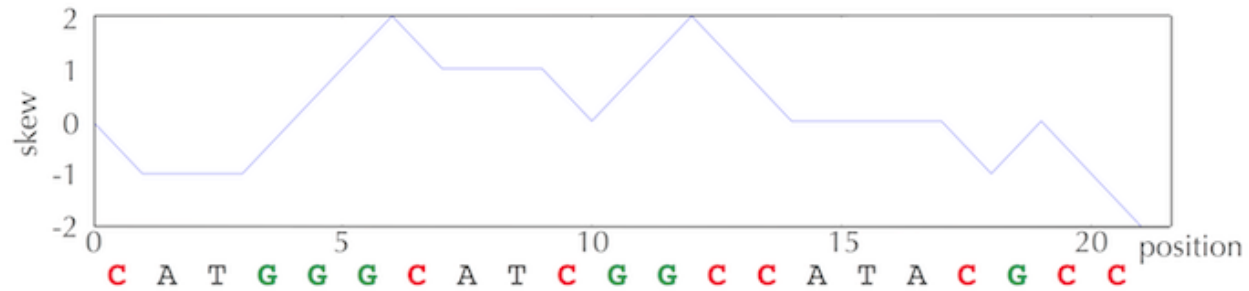
# Arreglando la deaminación



	C	G	A	T
<b>Entire strand</b>	427419	413241	491488	491363
<b>Reverse half-strand</b>	219518	201634	243963	246641
<b>Forward half-strand</b>	207901	211607	247525	244722
<b>Difference</b>	<b>+11617</b>	<b>-9973</b>	-3562	-1919

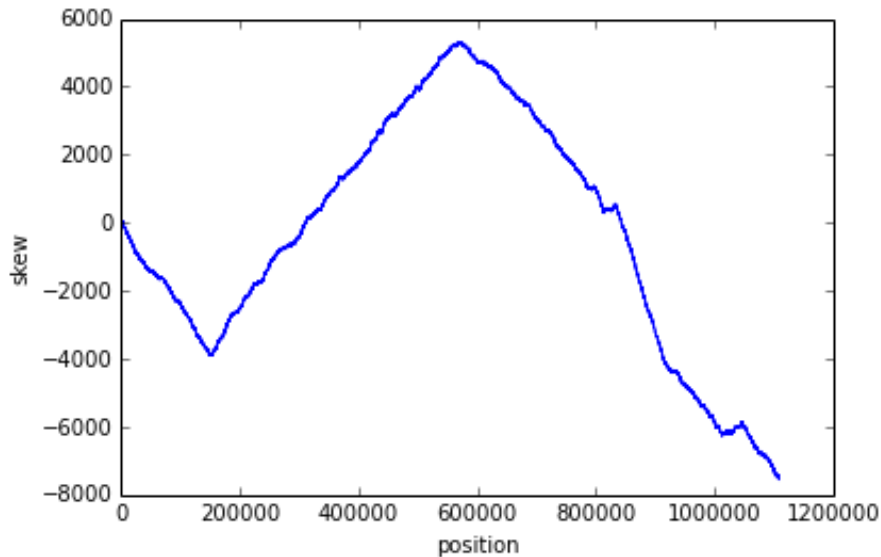
# de nucleótidos en *Thermotoga petrophila*

# Contando la deaminación

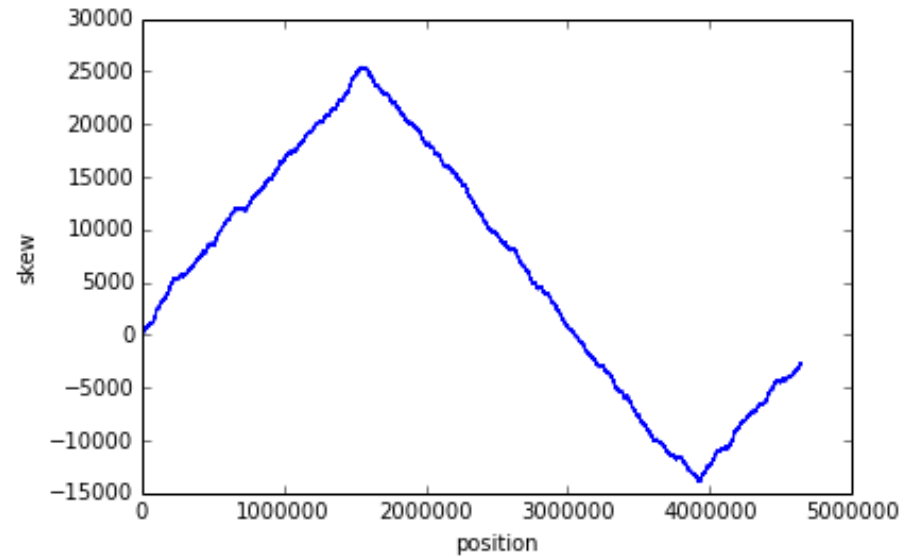


Buscar la  
mínima  
diferencia  
entre G y C

CATGGGCATCGGCCATACGCC → 0 -1 -1 -1 0 1 2 1 1 1 0 1 2 1 0 0 0 0 -1 0 -1 -2



*Vibrio cholerae*



*Escherichia coli*