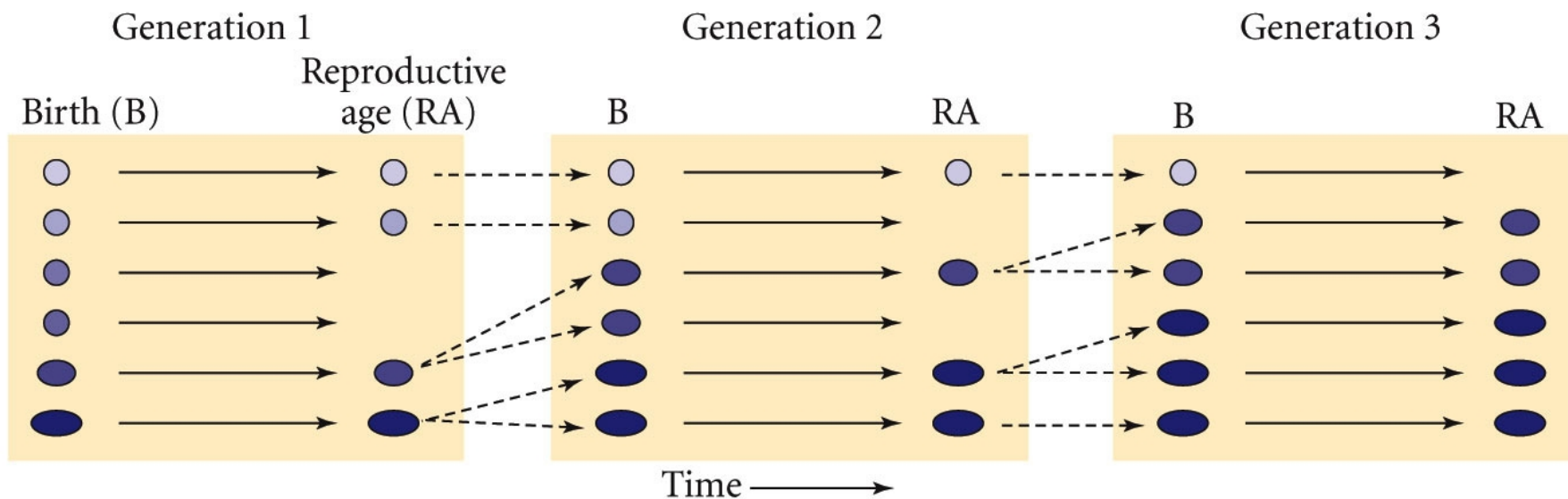


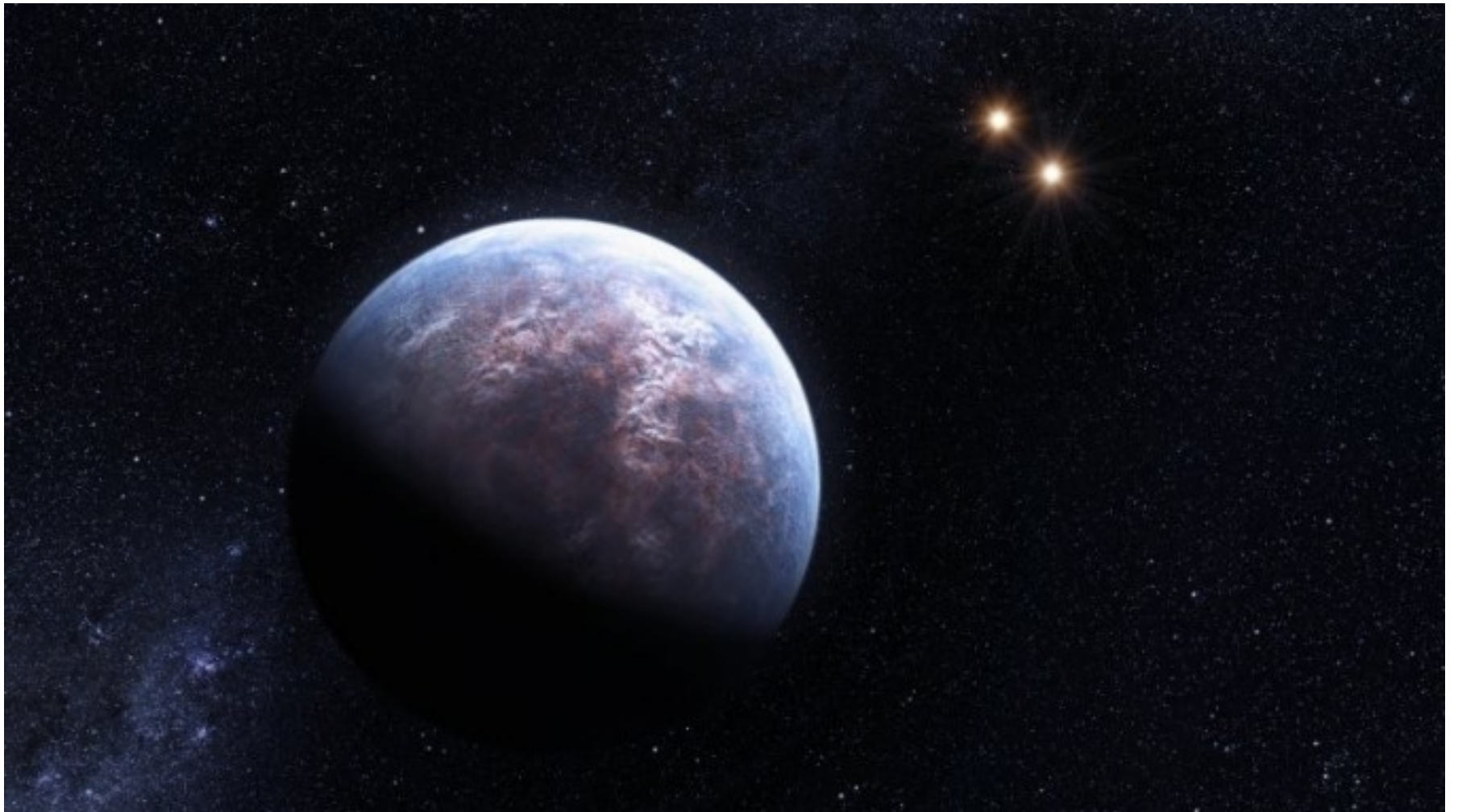
The evolution of living beings

Origin of living beings
Theory of Evolution
Cases of Evolution

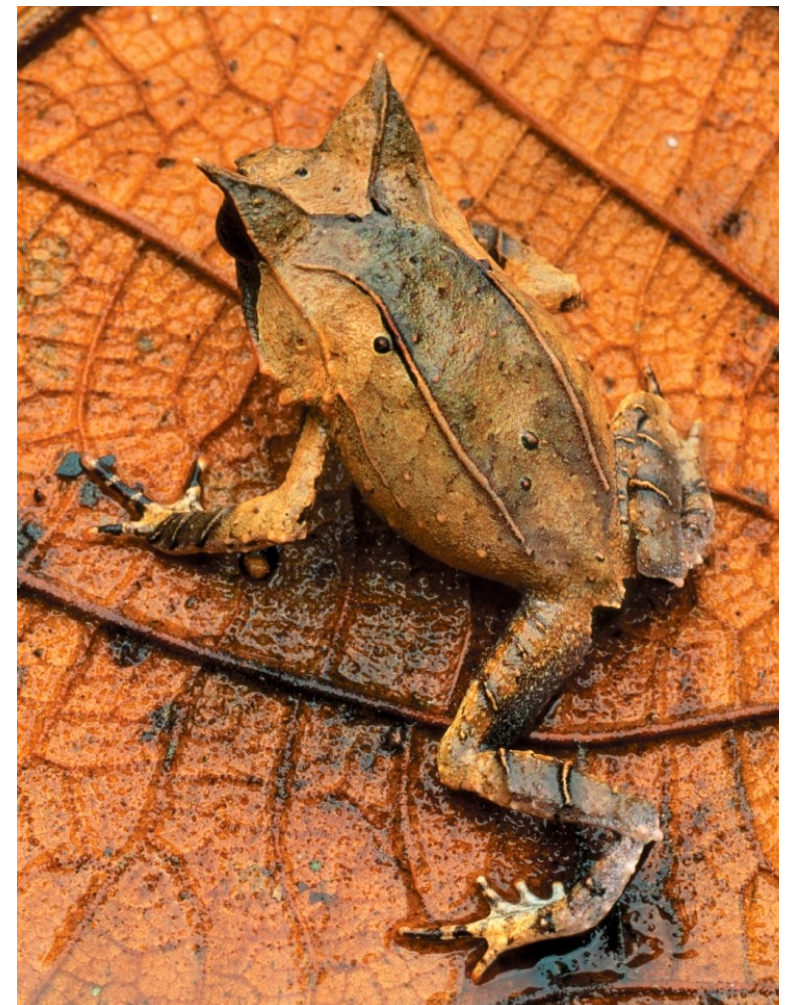


**V. Courtier-
Orgogozo**

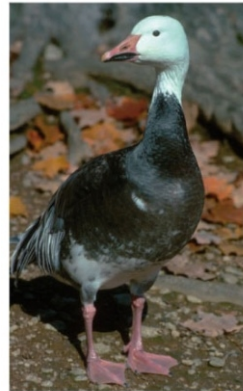
Comment la vie a-t-elle commencé ?



Comment expliquer que les êtres vivants soient si bien adaptés à leur environnement ?



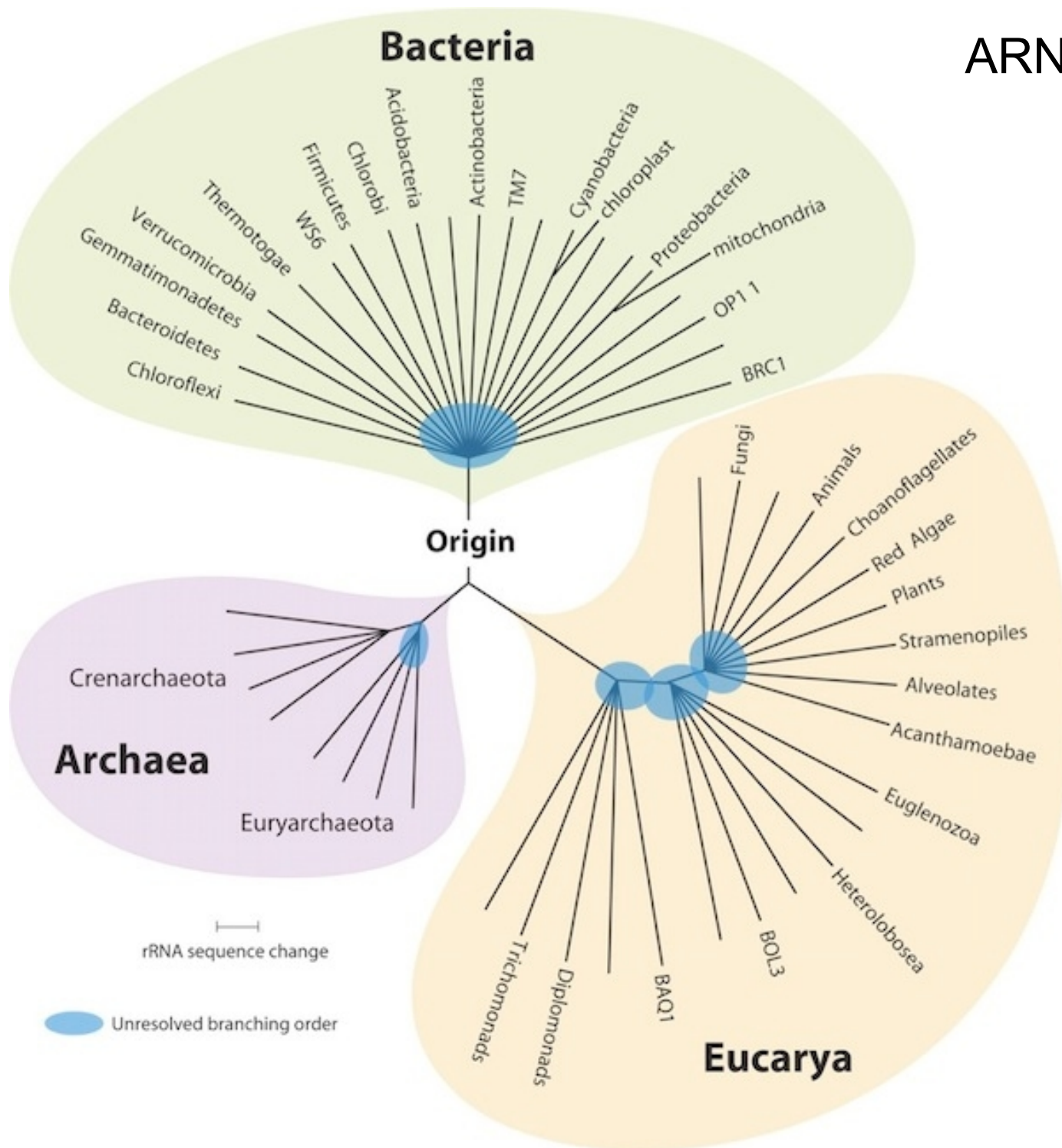
Pourquoi autant de variabilité phénotypique intra- et inter- espèce ?



The origin of living beings

The origin of living beings

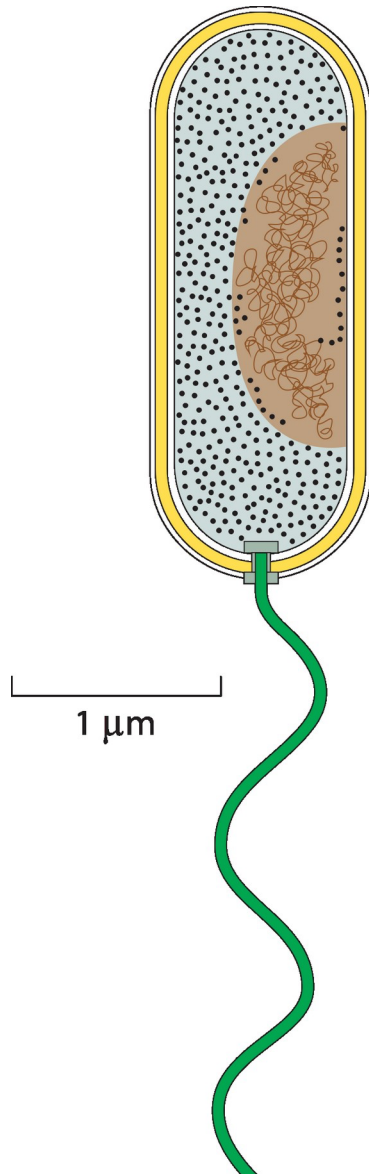
ARN 16S + 18S



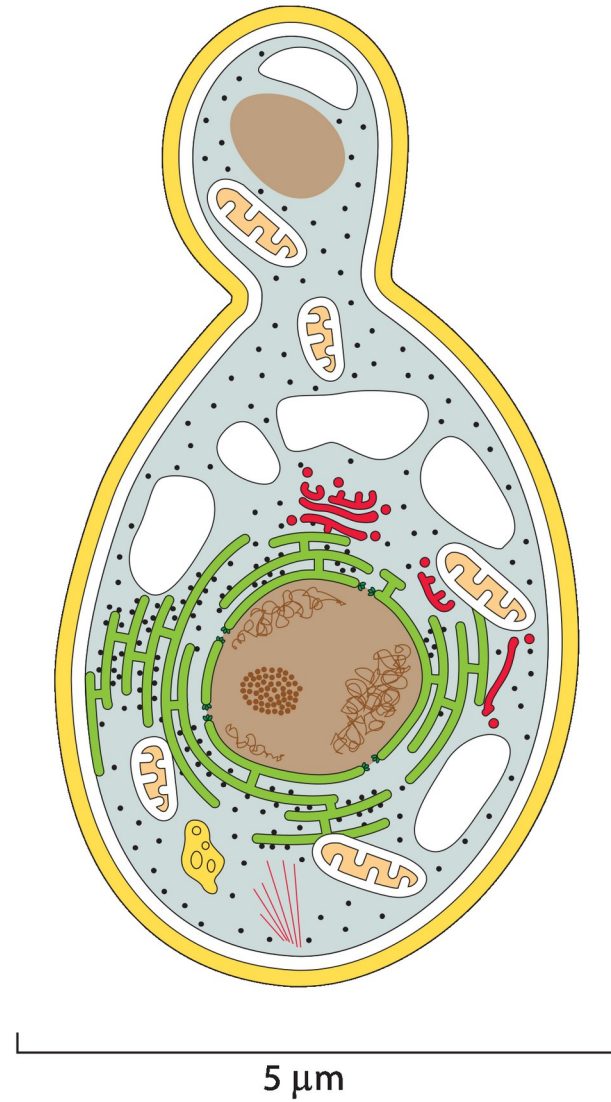
Impossible
d'ajouter les
virus

1977

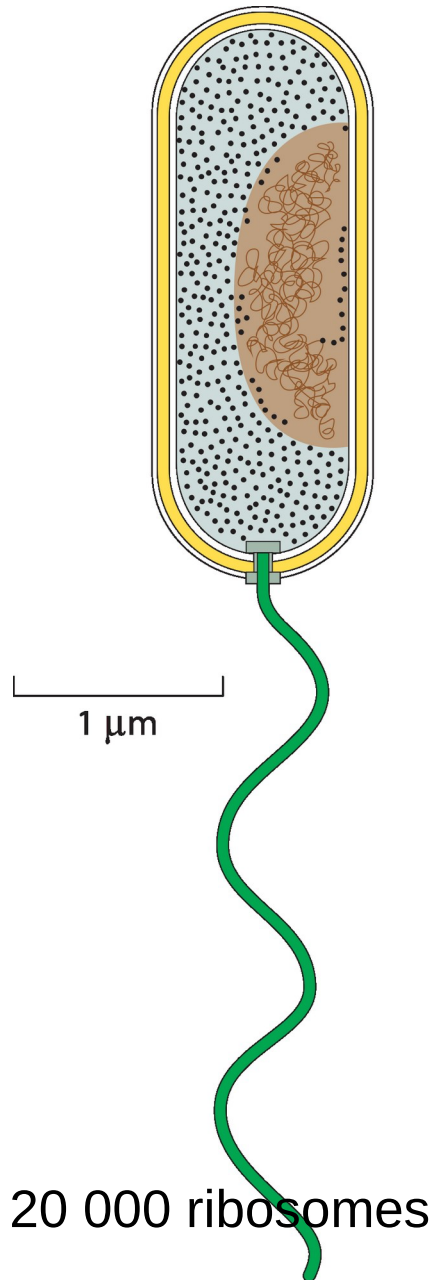
Une bactérie



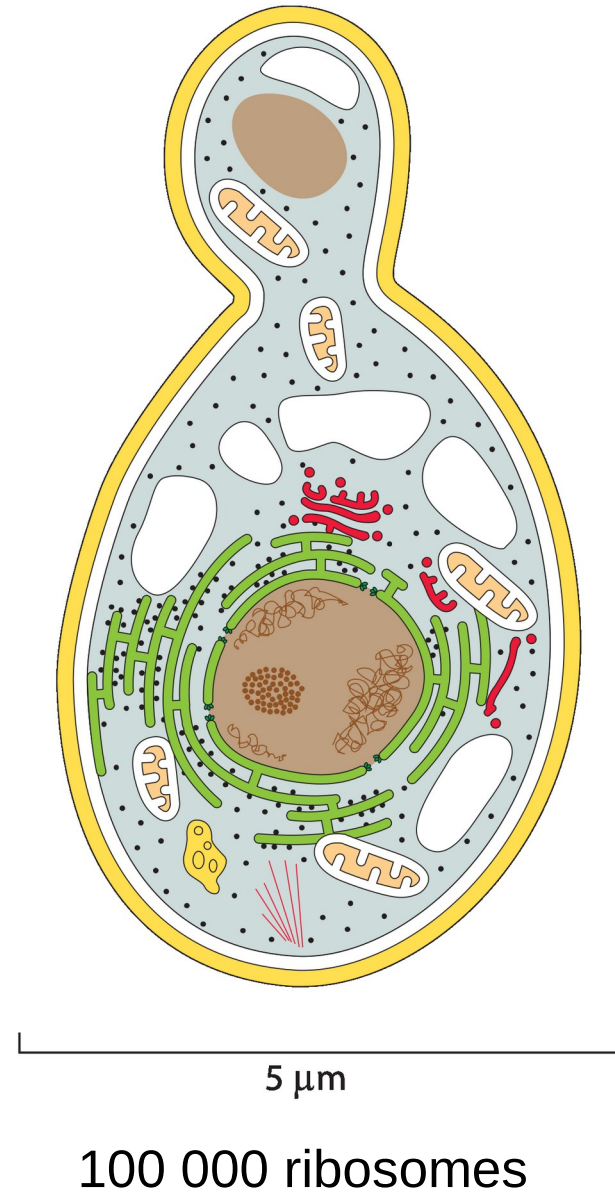
Une cellule de levure

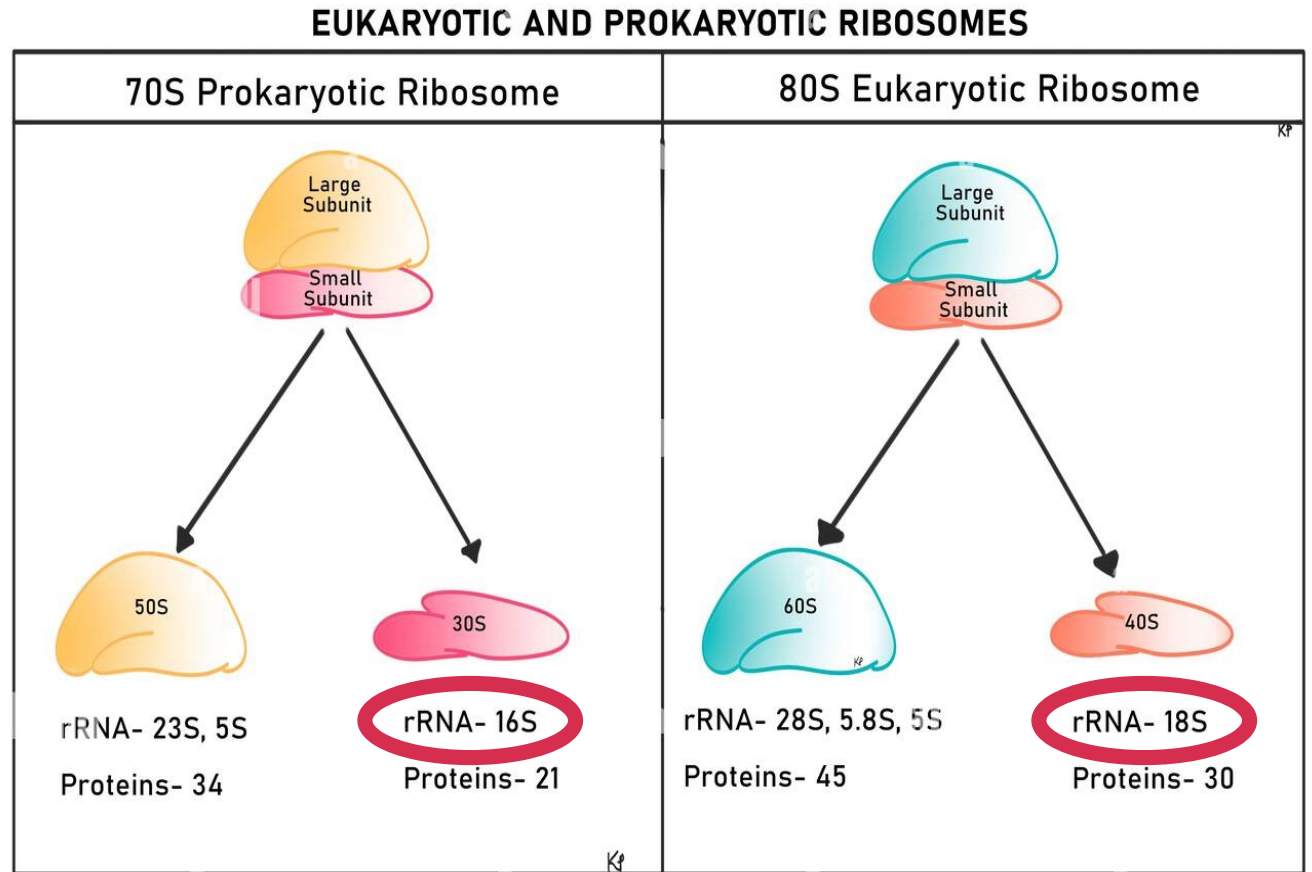
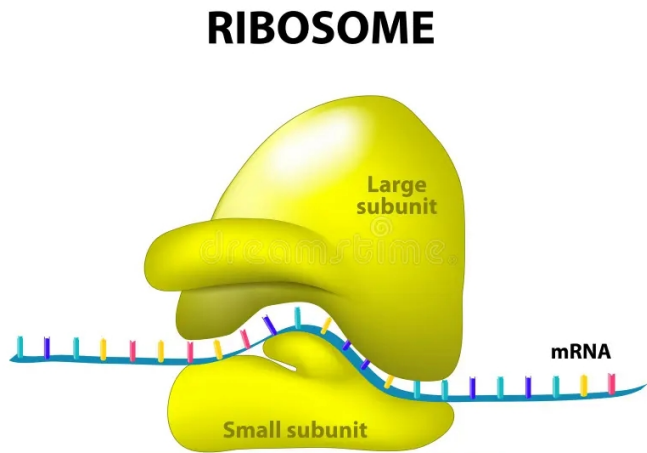


Une bactérie

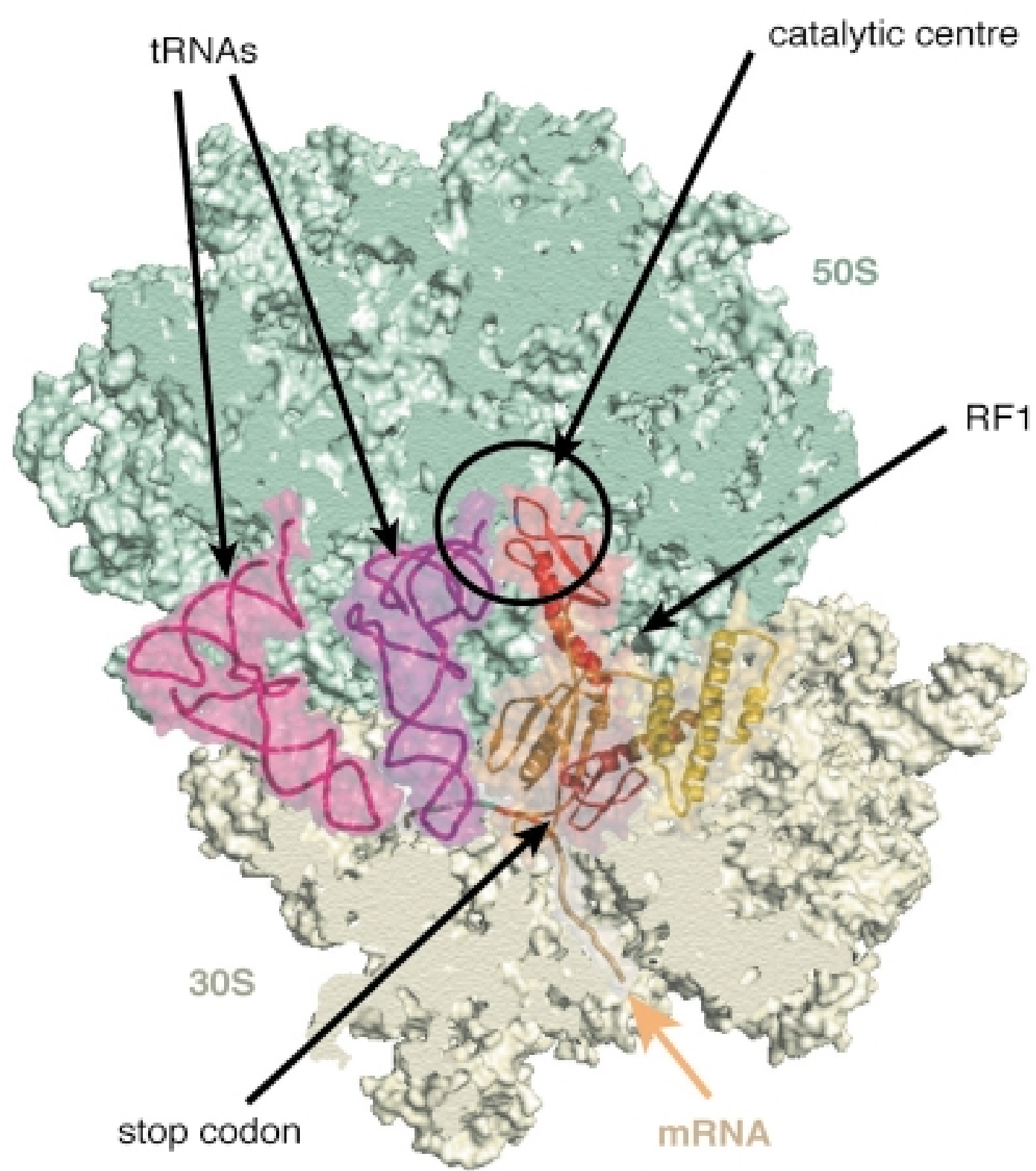


Une cellule de levure

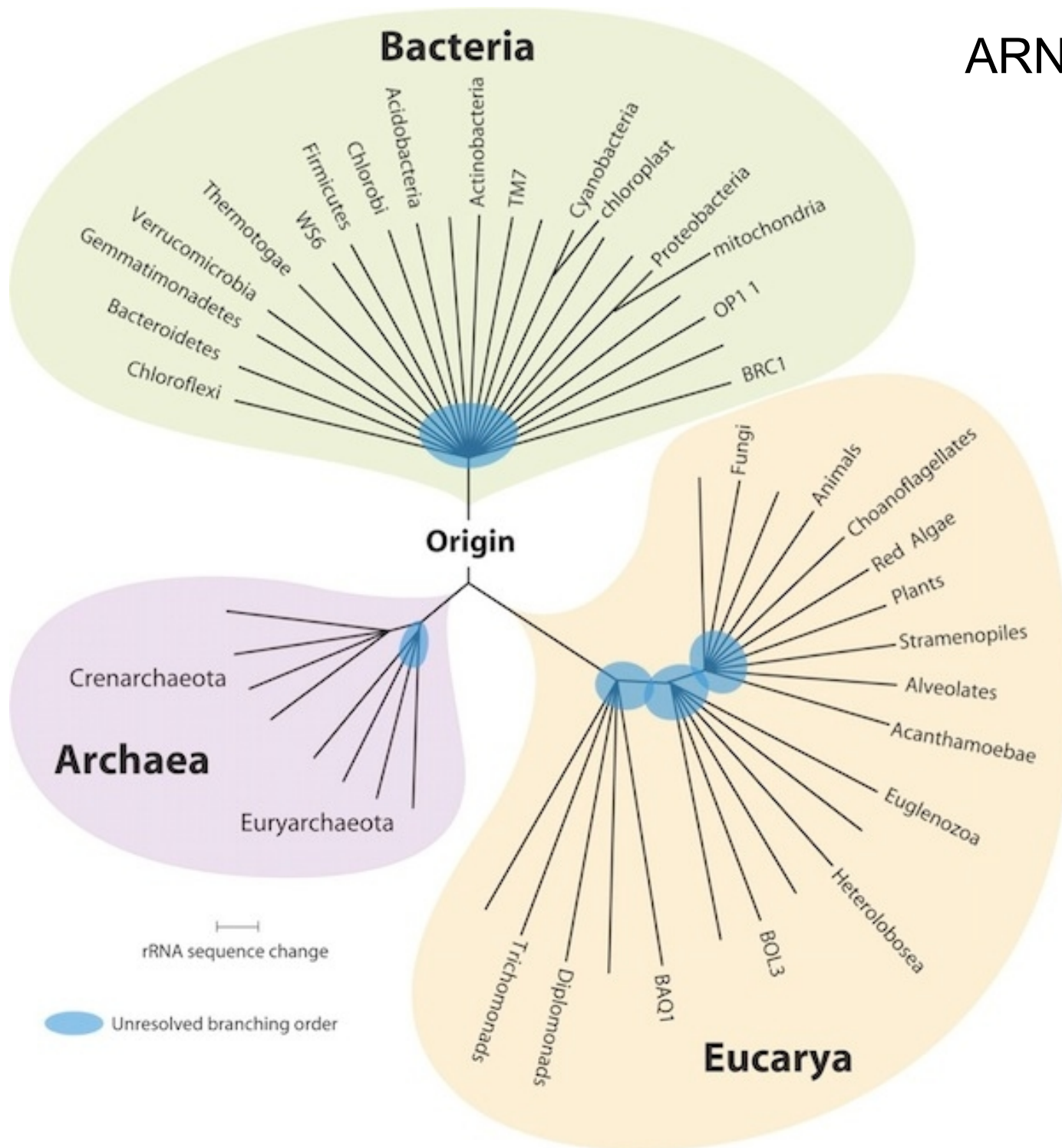




Bactéries, mitochondries : ARN 16S
Eucaryote : ARN 18S

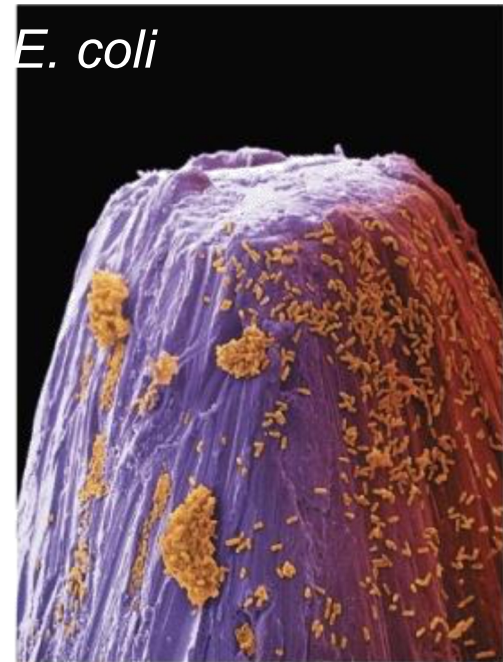
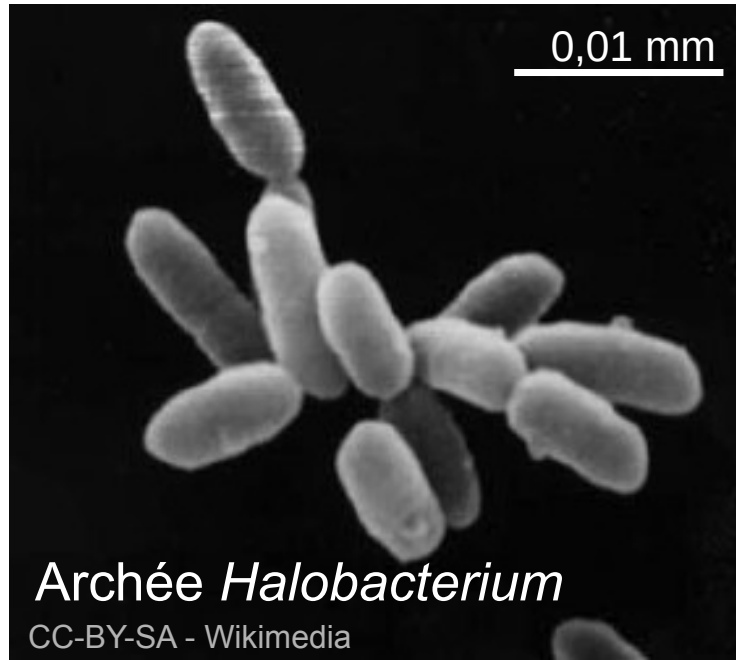


ARN 16S + 18S



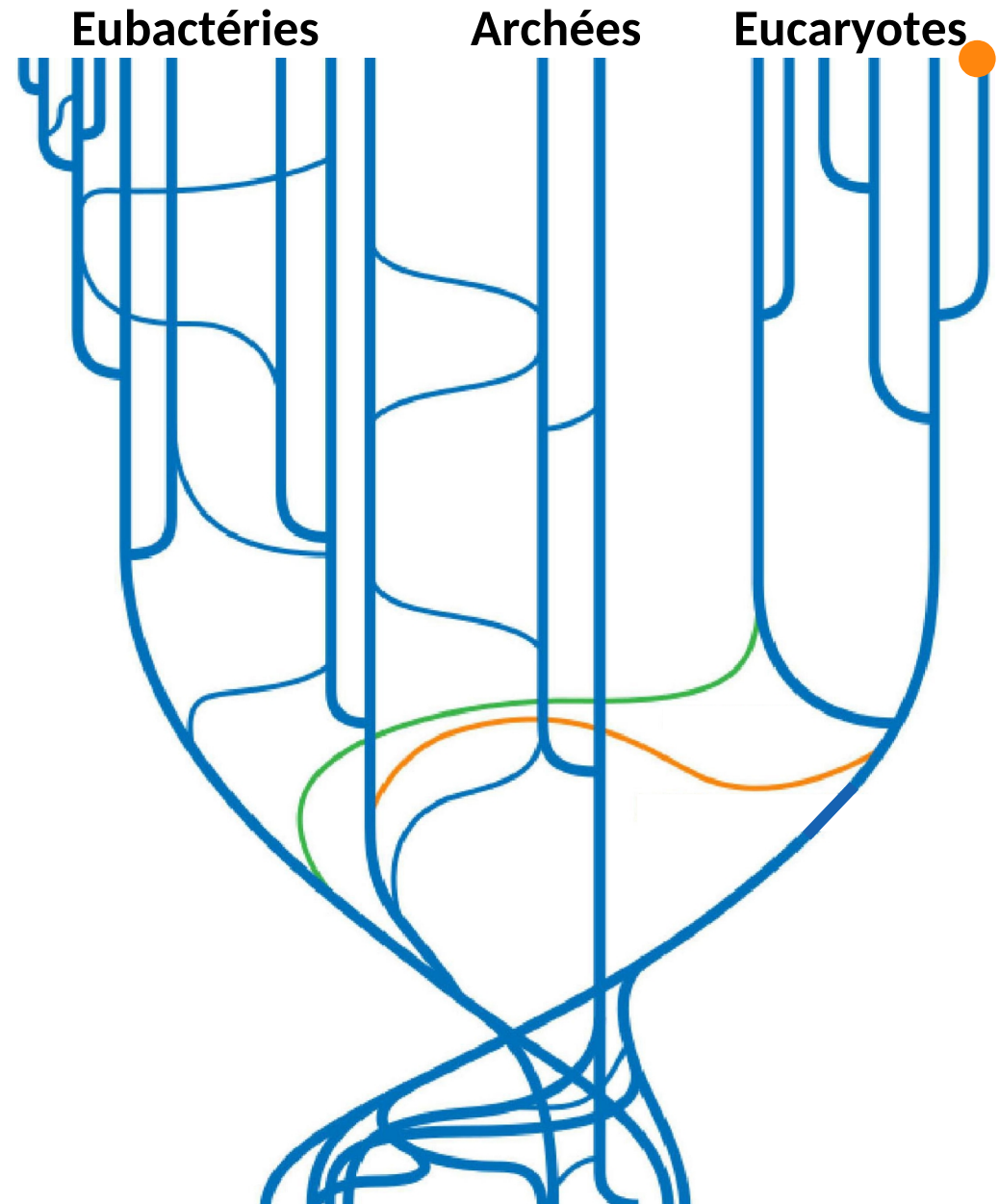
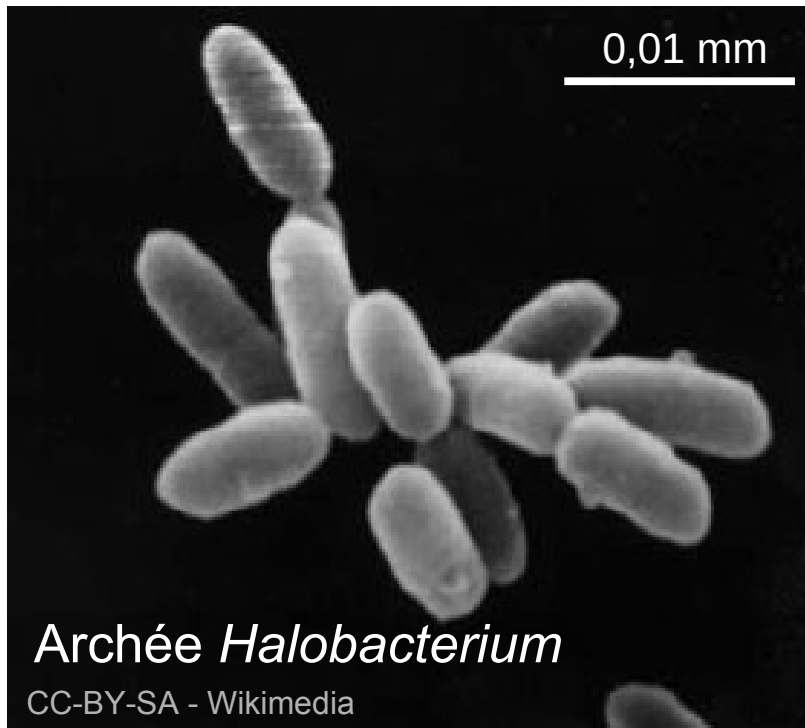
Impossible
d'ajouter les
virus

1977



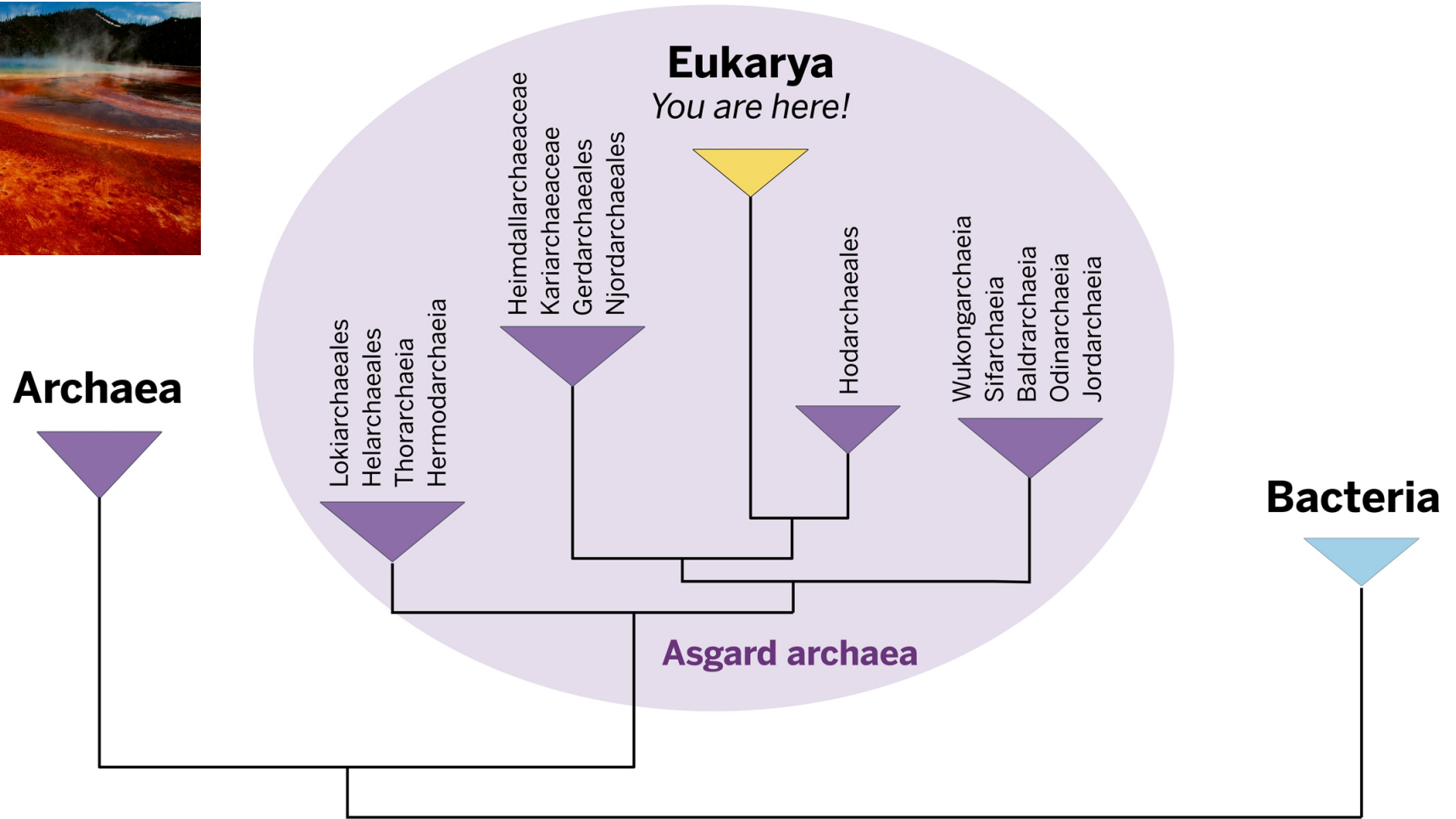
@T. Brian & D. Parker

L'arbre du vivant jusqu'à 2015



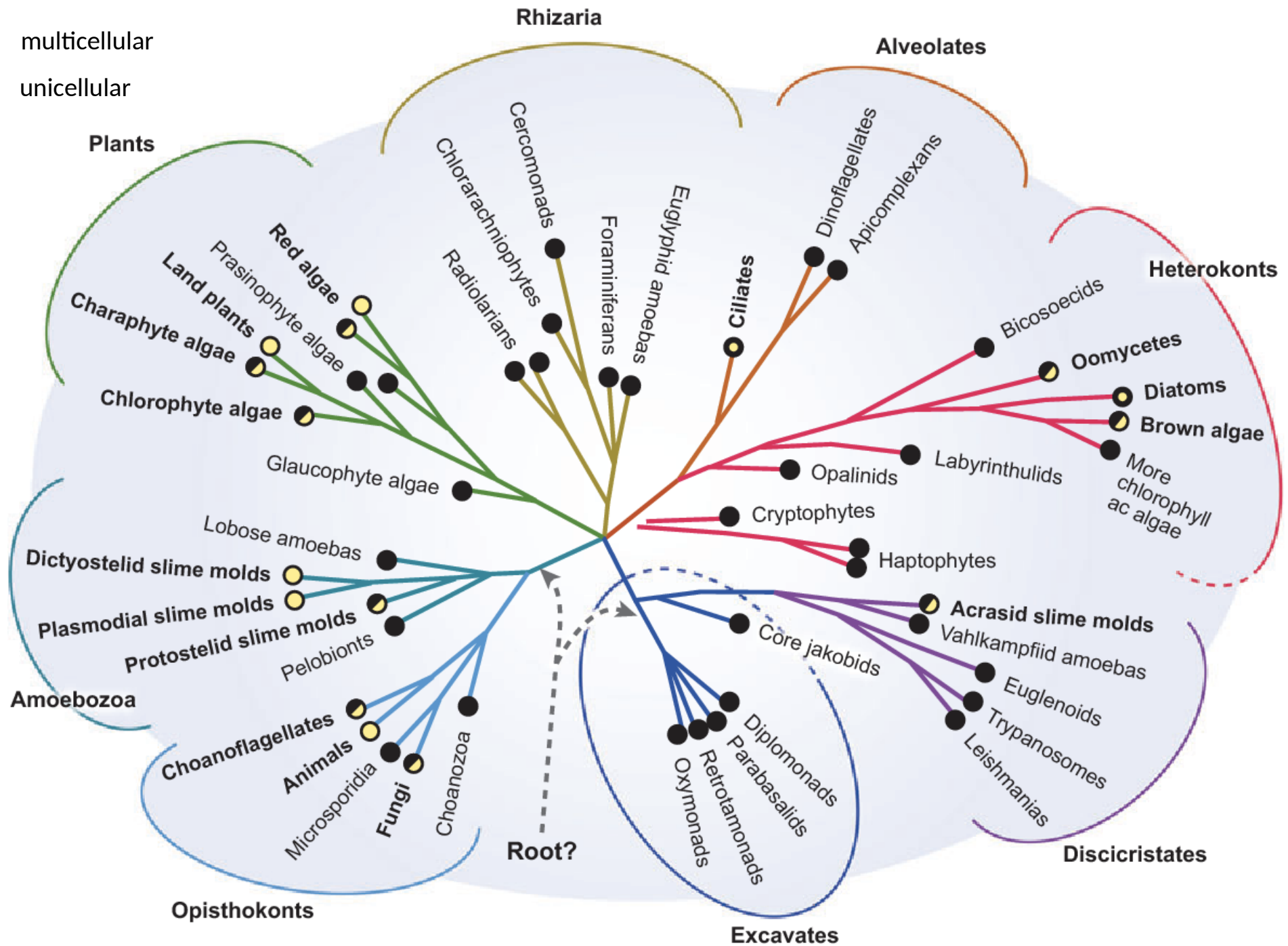
Communauté ancestrale de
cellules primitives

Le nouvel arbre du vivant



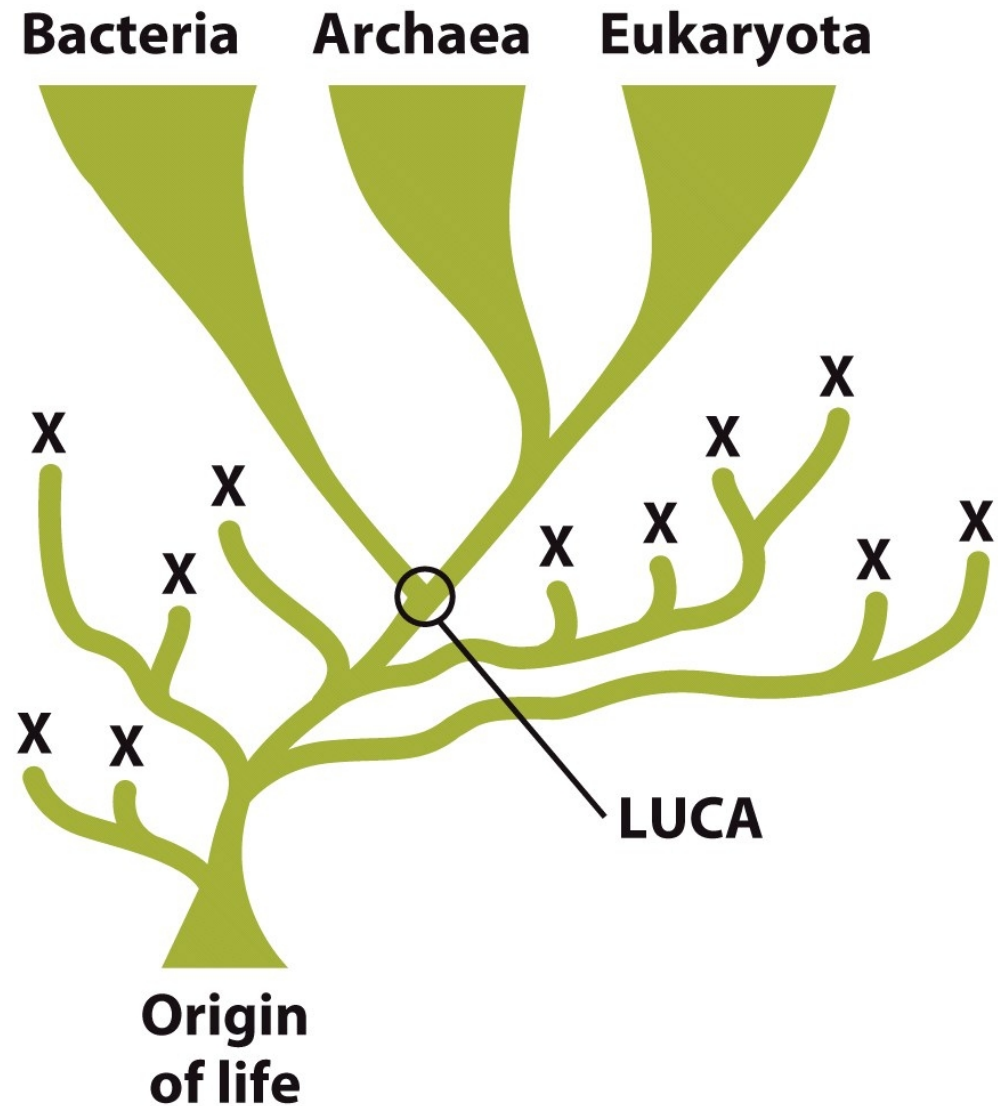
Premières archéobactéries Asgard trouvées dans des sédiments à 2 300 mètres de profondeur entre le Groenland et la Norvège en 2015

La multicellularité a évolué plusieurs fois



LUCA : Last Universal Common Ancestor

L'origine de la vie et
le dernier ancêtre
commun sont deux
événements distincts

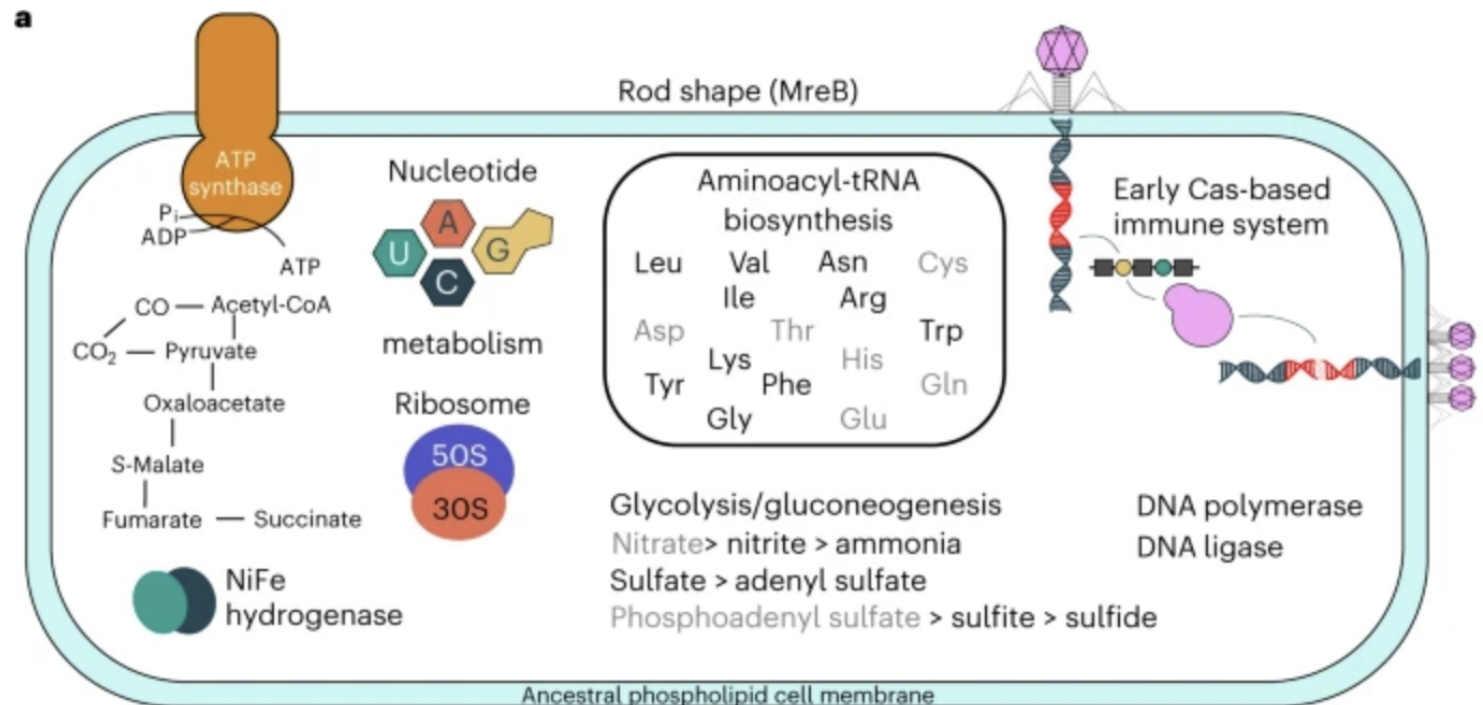
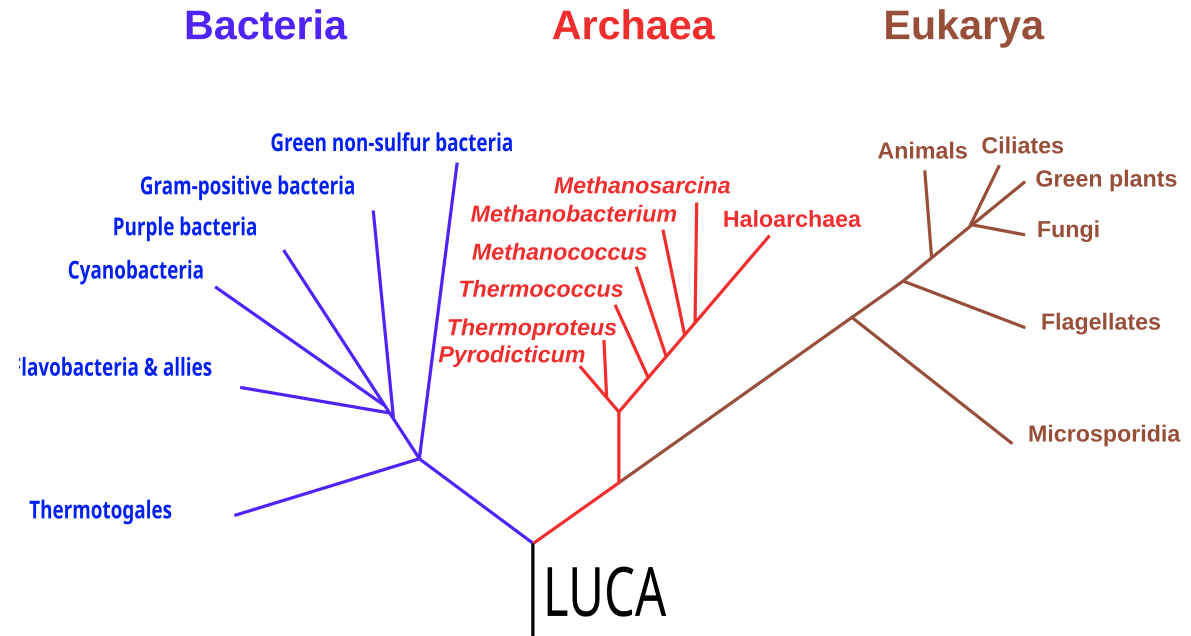


LUCA

Last Universal Common Ancestor

universal genetic code
 machinery for protein synthesis
 shared chirality of the almost-universal
 set of 20 amino acids
 use of ATP as energy currency

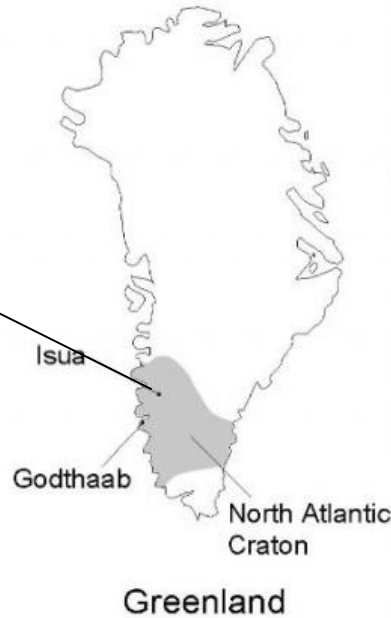
A genome of at least 2.5-3 Mb,
 encoding about 2,600 proteins



Les plus vieilles roches affleurant à la surface



3,80 MMA



Slave Craton

4,03 MMA



3,60 MMA

Pilbara Block

Yilgarn Block

Australia

<http://gustavus.edu>



4,5

milliards d'années

formation
de la terre

Les plus vieilles traces de vie

3,48MMA: Biofilm



(Noffke et al. 2013)

3,7MMA: Graphite biogénique



(Ohtomo et al. 2013)

3,80 MMA



4,03 MMA



3,48 MMA



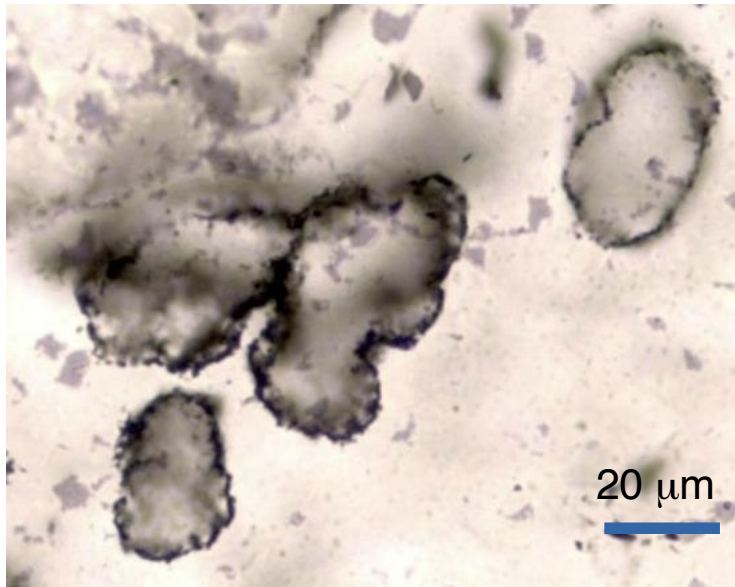
<http://gustavus.edu>



4,5
3,7
milliards d'années

1ères traces (graphite)

Premières cellules fossilisées : 3,4 MMA



(Wacey et al. 2011)



Strelley Pool Formation, Australie



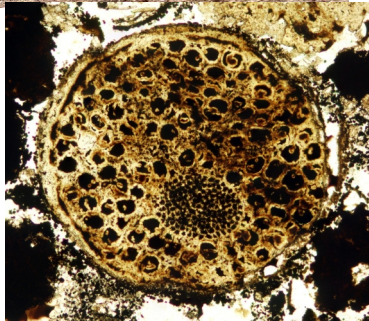
Roche couverte de concrétions d'hématite

Par évaporation rapide
d'eau riche en fer
dissous

Roche (récente)
provenant d'Arabie
saoudite, MNHN



Fossiles d'Ediacara : 630-540MA



<http://commons.wikimedia.org/>

4,5 3,7 3,4 630-540

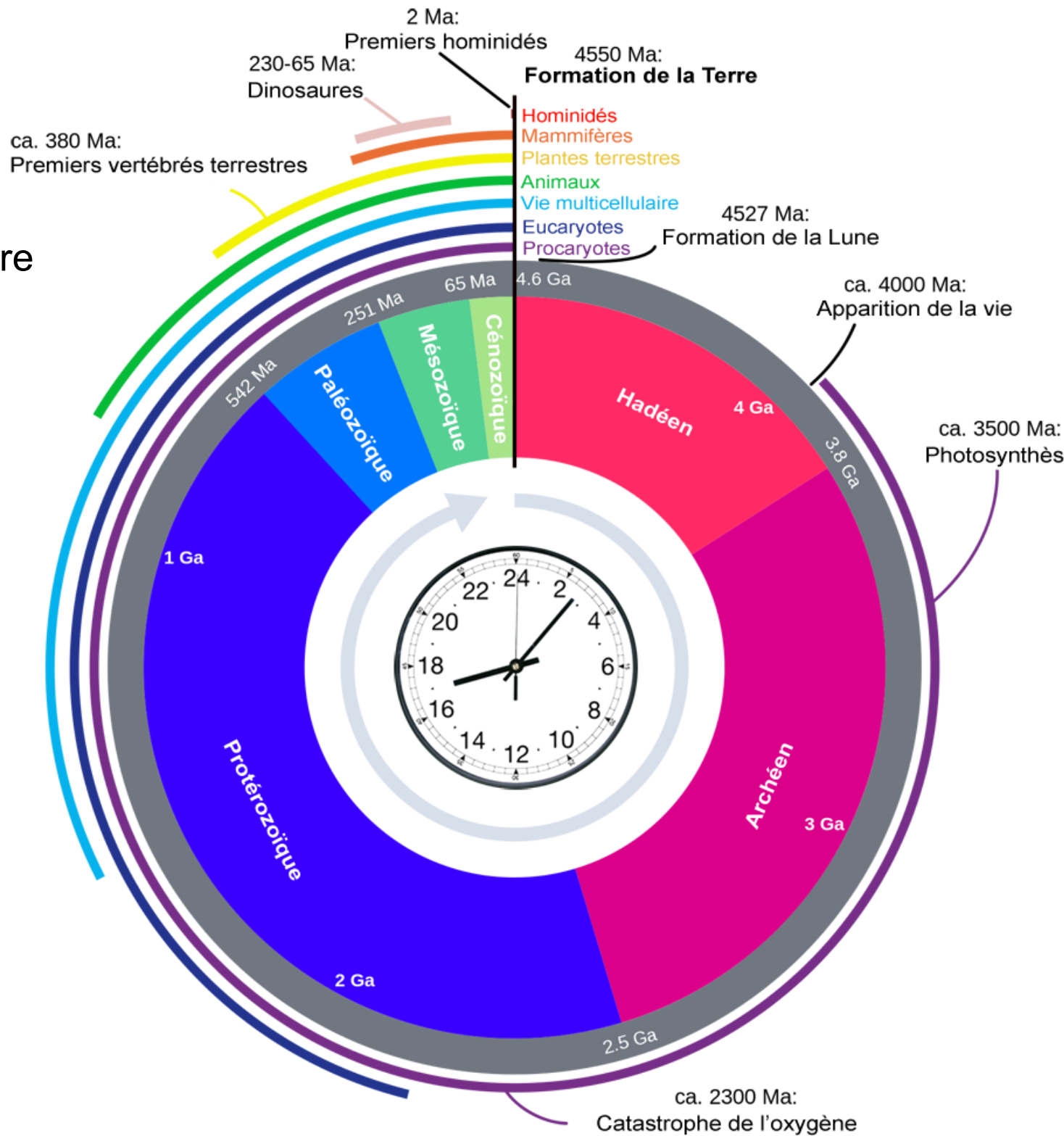
milliards d'années

1ères traces (graphite)
1ères cellules fossiles

1ers fossiles complexes
faune d'Ediacara

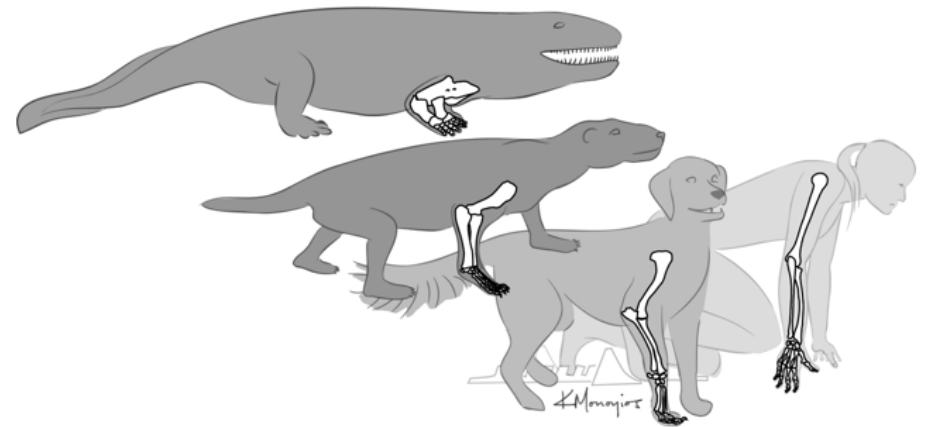
0h00 : formation de la Terre
 4h10 : apparition des
 premières formes de vie
 17h45 : apparition des
 premiers organismes
 multicellulaires
 23h40 : disparition des
 dinosaures

23h59 et 56 secondes :
apparition des premiers
hommes

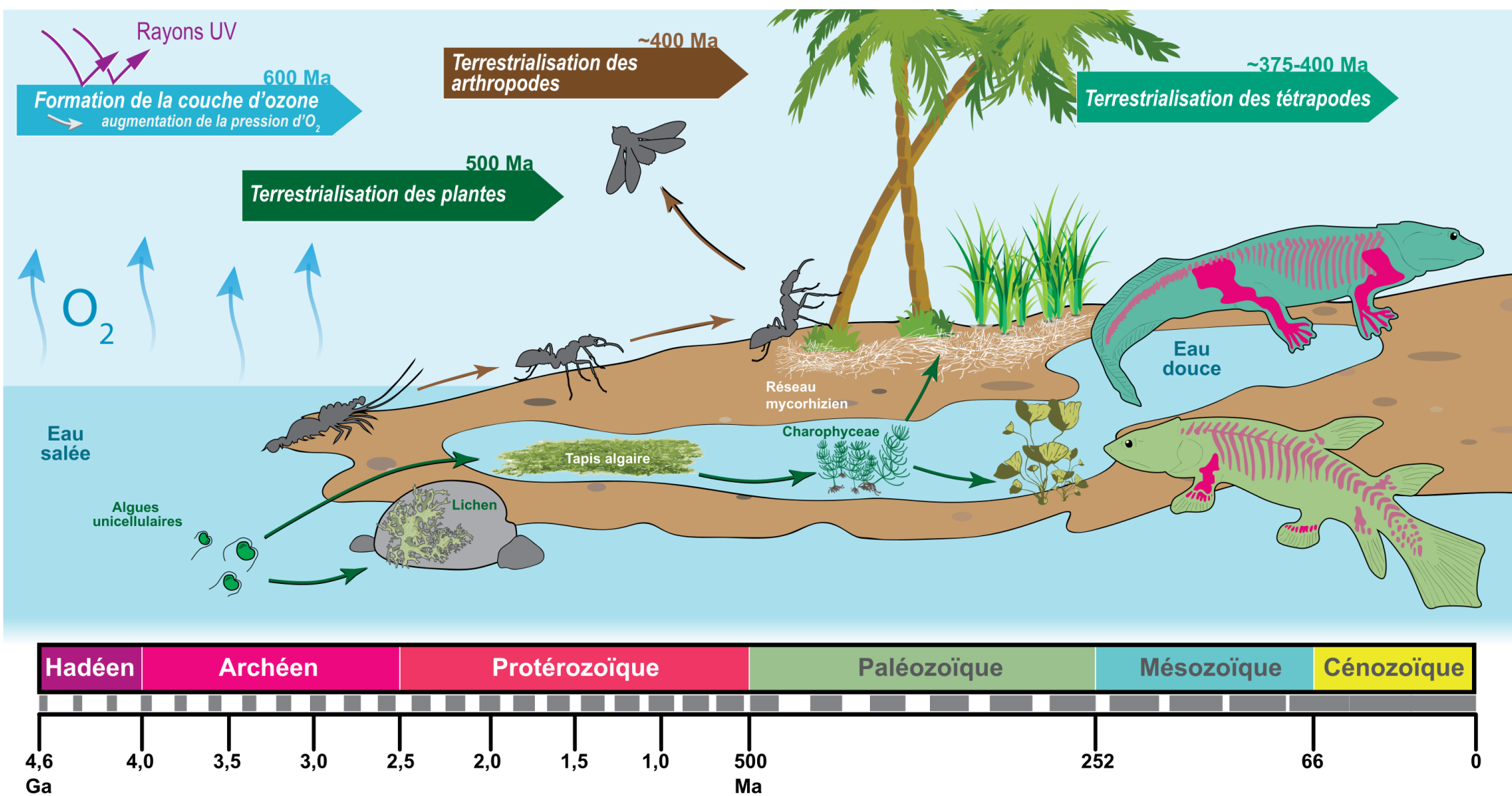


Conquête du milieu terrestre indépendamment par :

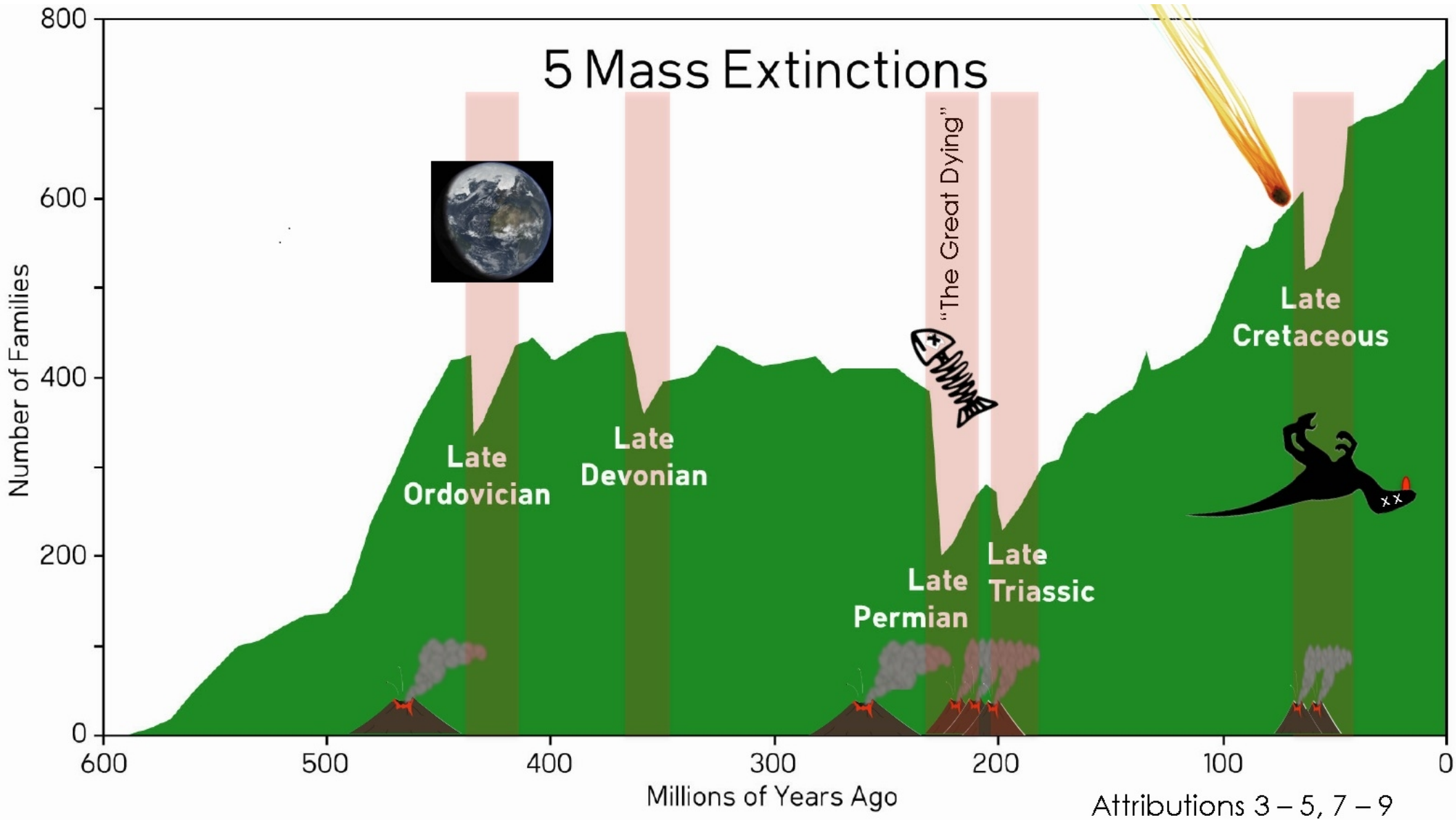
- Insectes
- Vertébrés
- Plantes
- Lichens



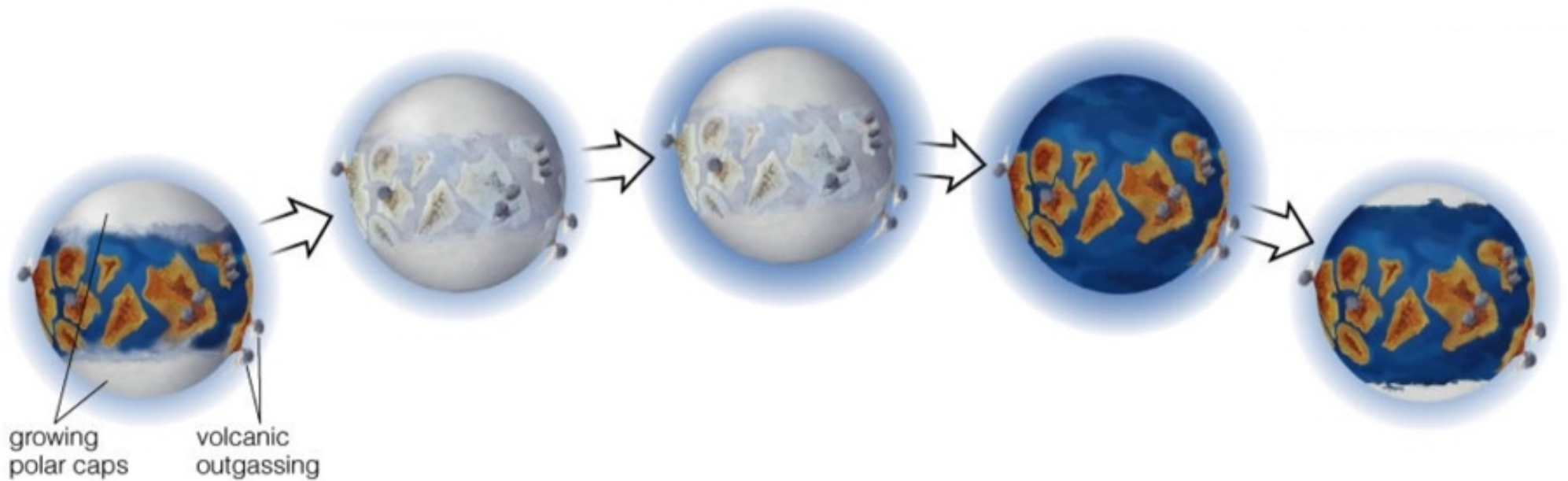
Dans quel ordre ?



Cinq grandes extinctions



Terre boule de neige



© 2006 Pearson Education, Inc., publishing as Addison Wesley

vers -2 MMA et -700 MA (Cambrien)

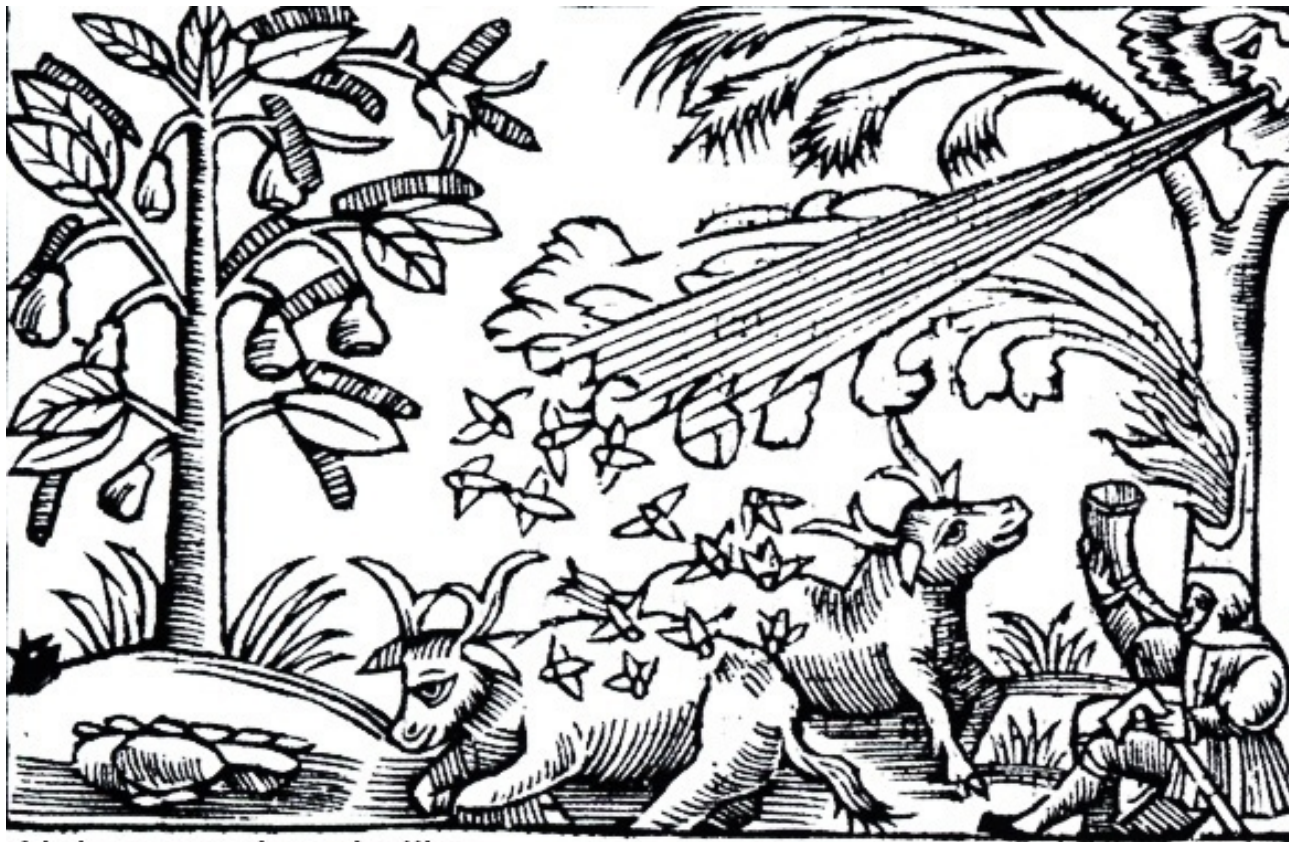
Explique la présence de de sédiments d'origine apparemment glaciaire, découverts à des paléolatitudes tropicales

The theory of evolution

Fixisme

Espèces créées par Dieu et immuables





Naissance des abeilles

(gravure sur bois 1555 - Olaus Magnus "Historia")

Légende de la naissance des abeilles dans le cadavre d'un taureau



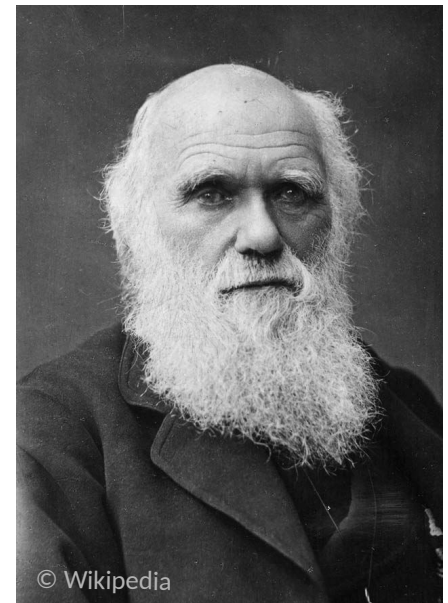
Jamais de nouvelles formes qui n'avaient pas existé auparavant.

The theory of evolution

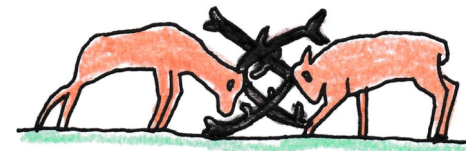
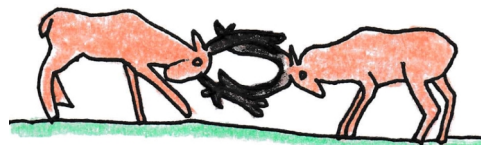
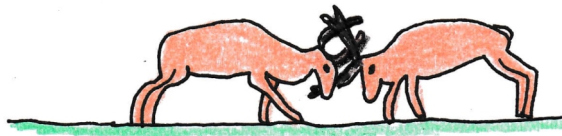
A new explanation for the diversity of living beings

Tremendous variation in traits

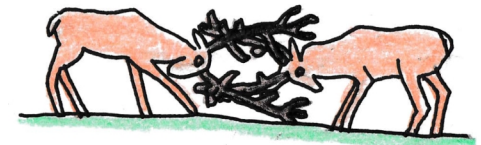
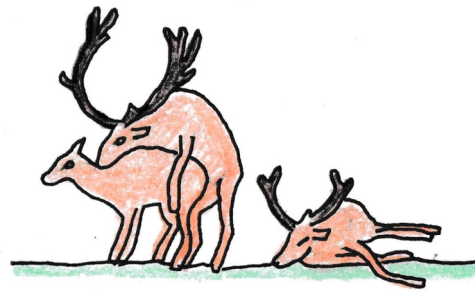
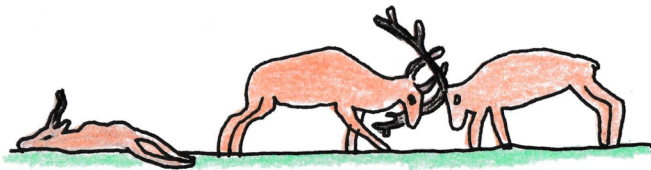
Many individuals do not survive



Lamarck



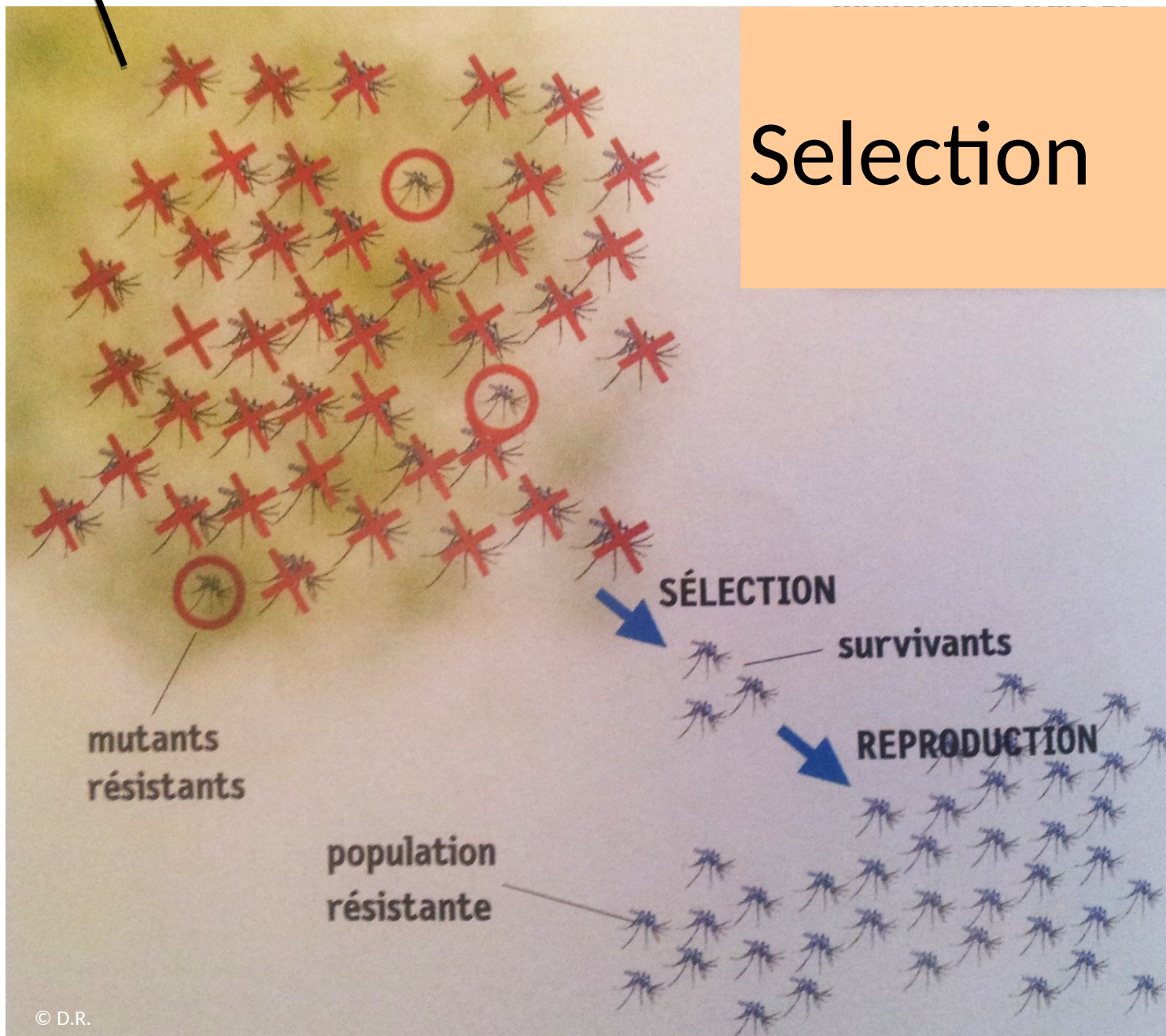
Darwin
&
Wallace

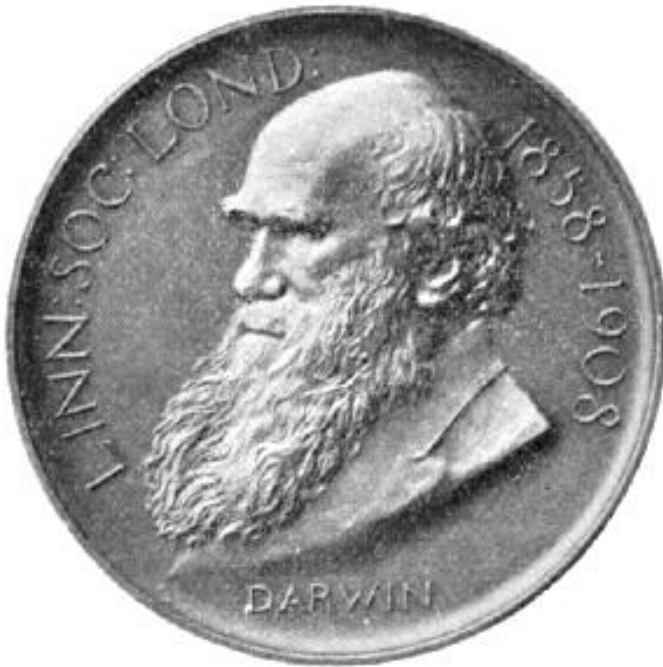


© V.C.

Insecticide

Selection

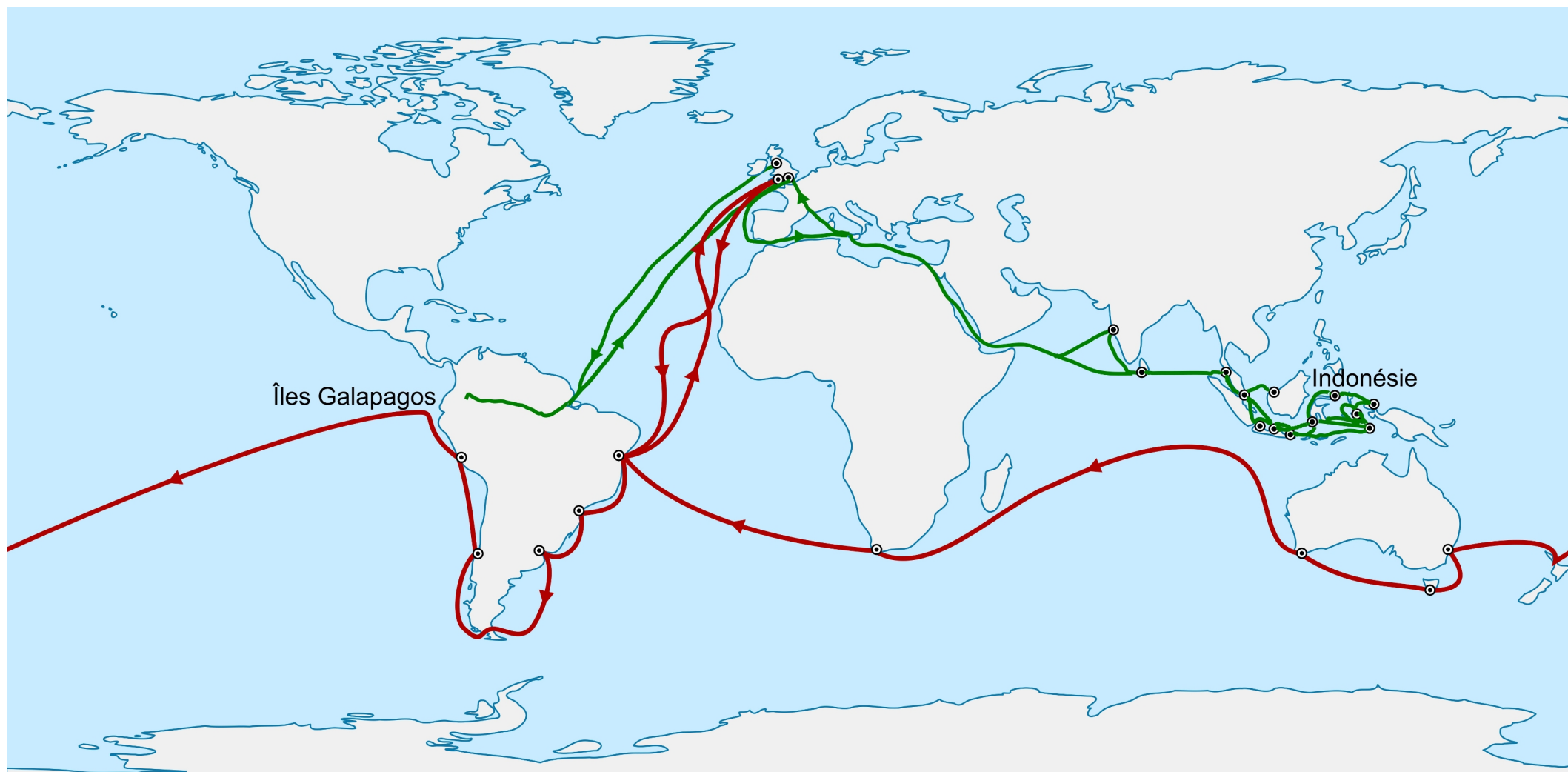




Charles Darwin (1809-1882)



Alfred R. Wallace (1823-1913)



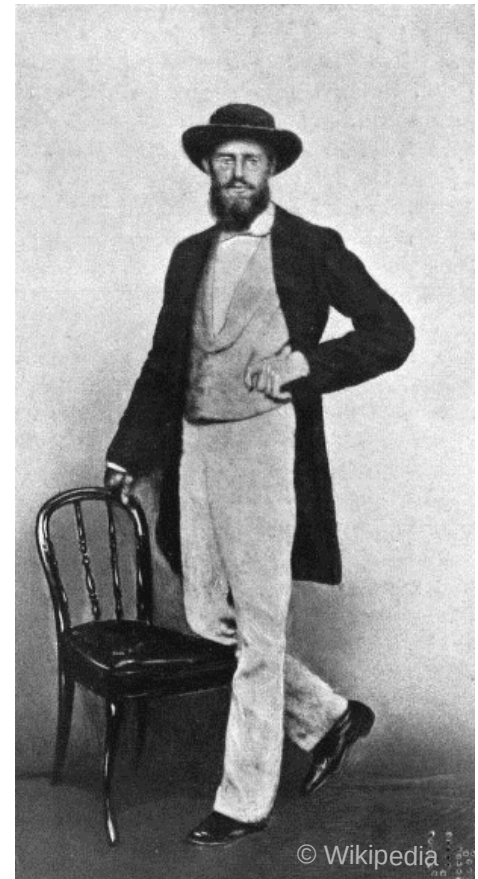
Adapté de Wikipedia

- Darwin : 5 years on Beagle (1831-1836)
- Wallace : Brazil (1848-1852), Malaysia et Indonésie (1854-1862)

"Places not more than fifty or a hundred miles apart often have species of insects and birds at the one, which are not found at the others. There must be some boundary which determines the range of each species; some external peculiarity to mark the line which each one does not pass."

"In all works on Natural History, we constantly find details of the marvellous adaptation of animals to their food, their habits, and the localities in which they are found. But naturalists are now beginning to look beyond this, and to see that there must be some other principle regulating the infinitely varied forms of animal life."

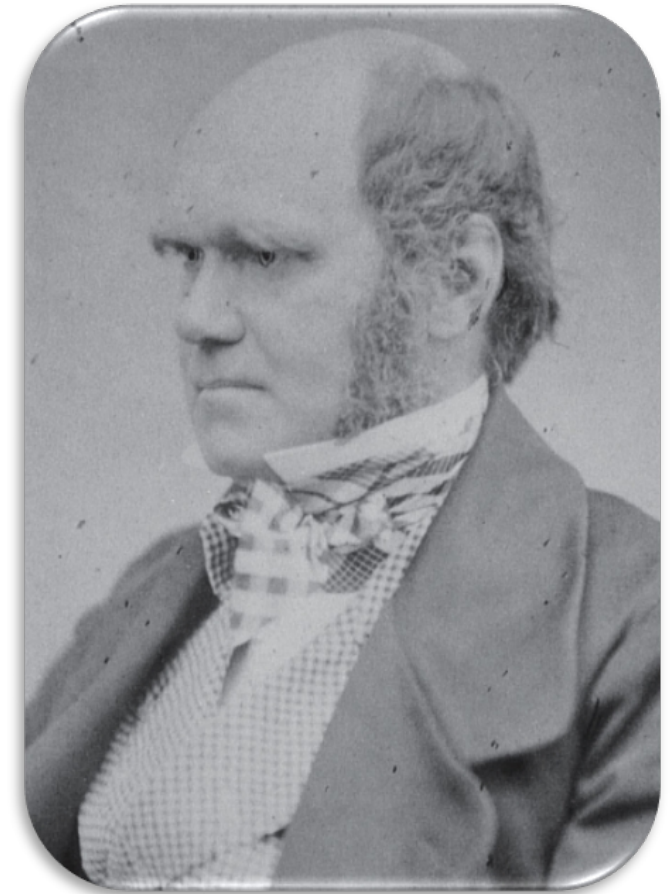
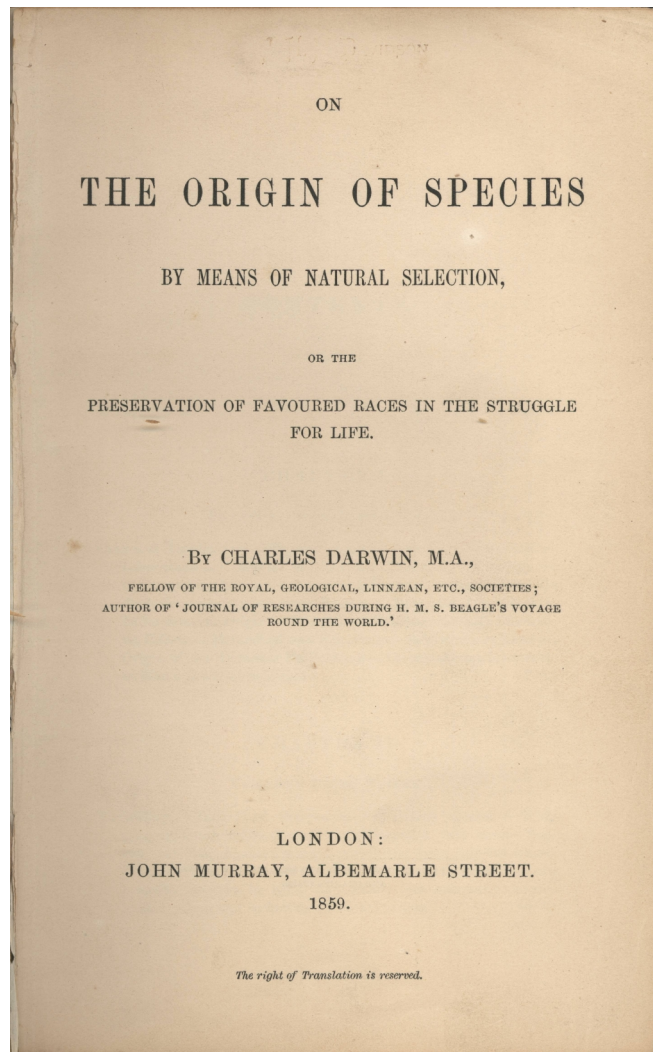
Alfred R. Wallace



Charles Darwin

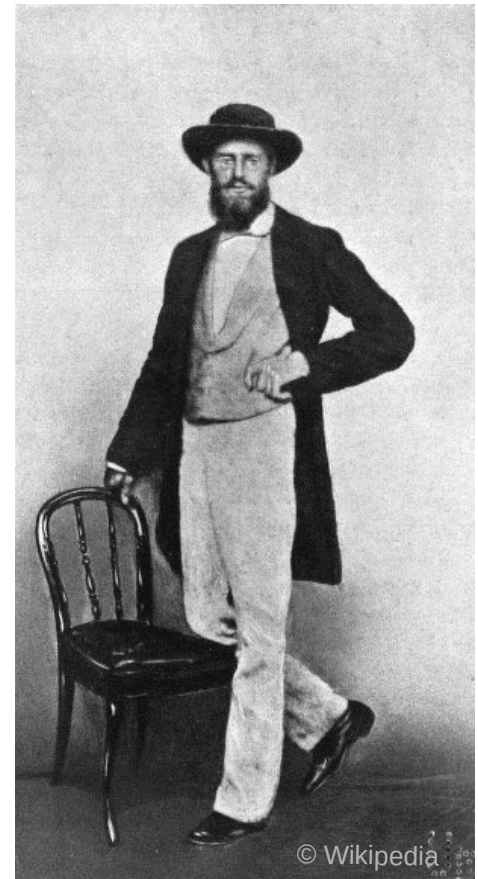
1859

« The origin of species »



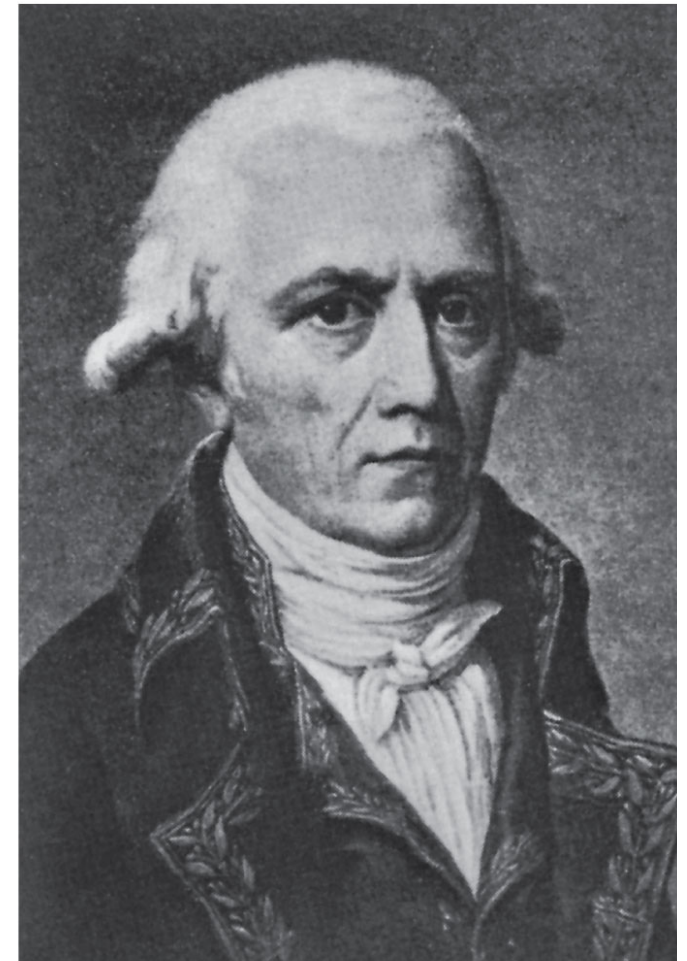
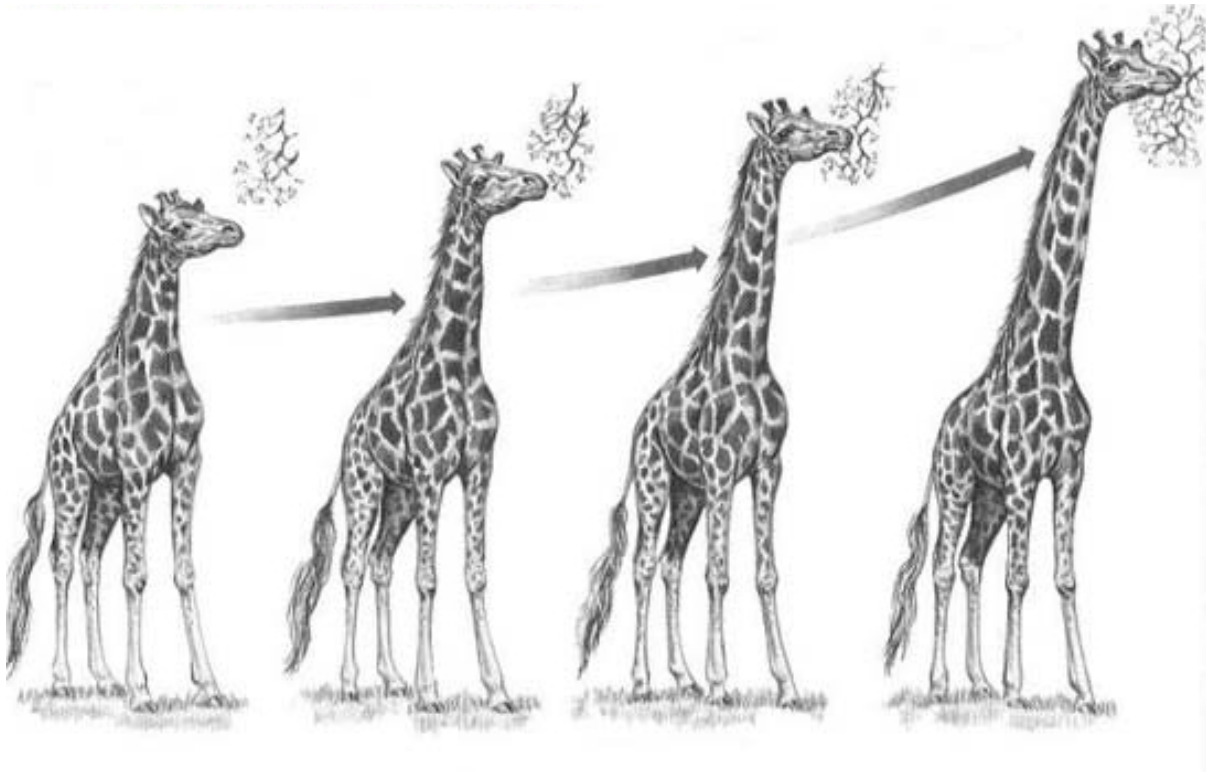
"I could never have approached the completeness of his book—its vast accumulation of evidence, its overwhelming argument, and its admirable tone and spirit. I really feel thankful that it has not been left to me to give the theory to the public."

Letter of Alfred R. Wallace to a friend, H.W. Bates

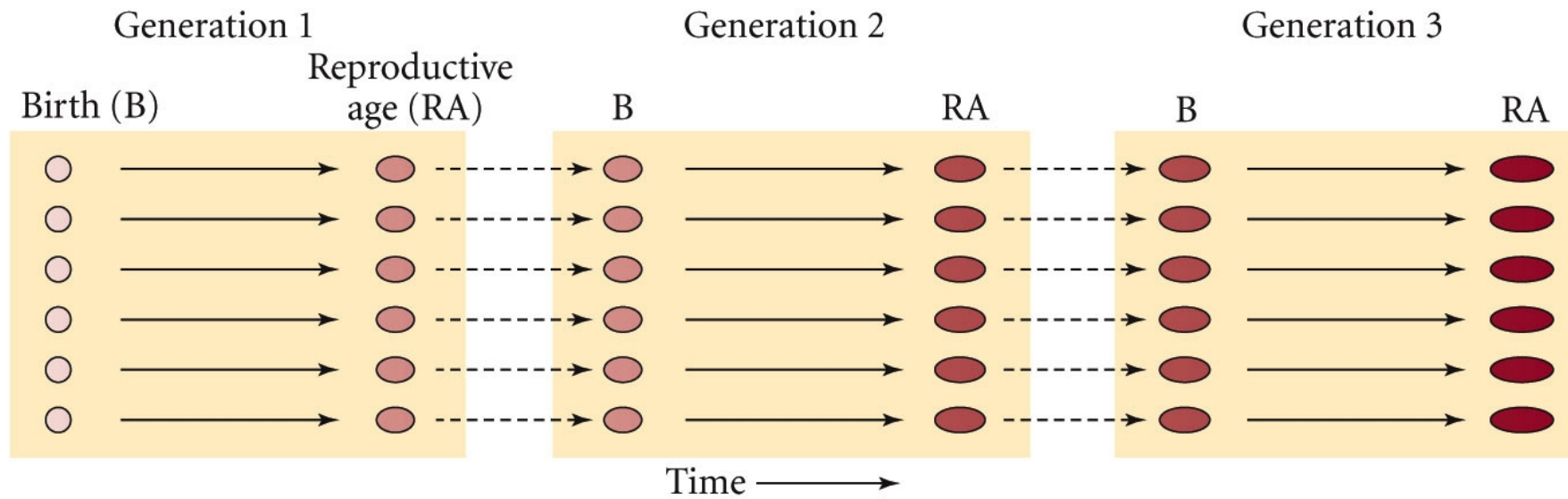


Jean-Baptiste Lamarck (1744-1829)

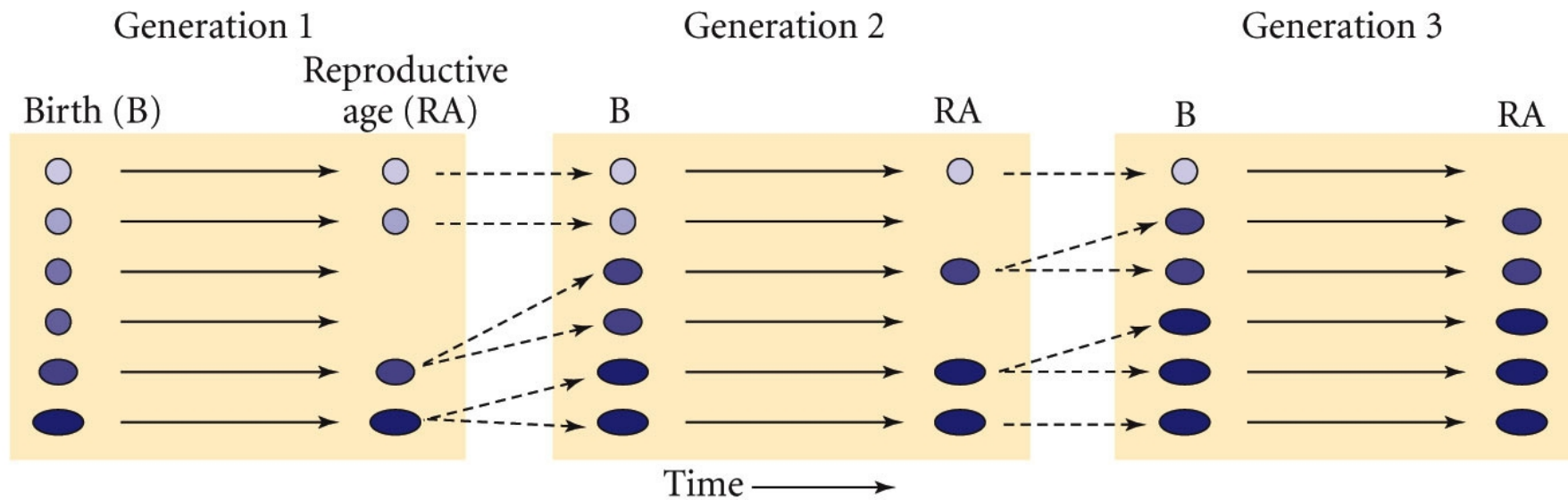
Hérédité des caractères acquis



Transformational evolution



Variational evolution



Les trois piliers de l'évolution

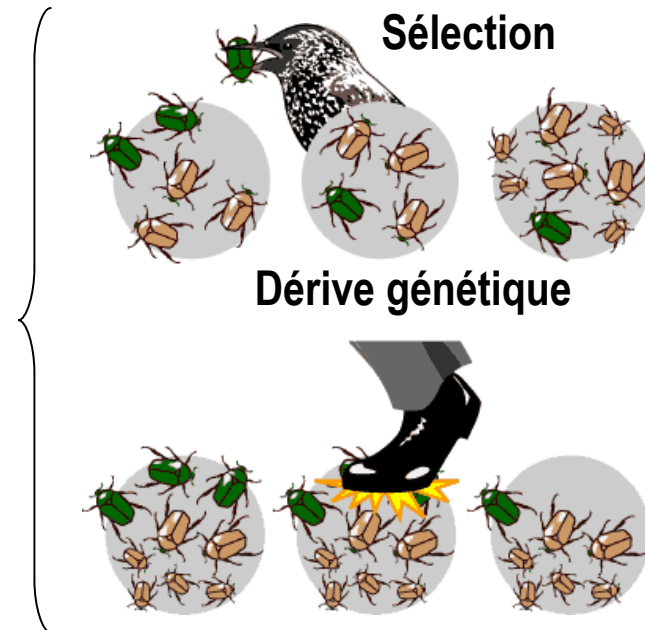
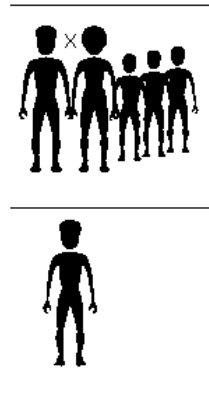
Variation

Mutations de l'ADN

Transmission



Reproduction
différentielle



Les 4 forces évolutives

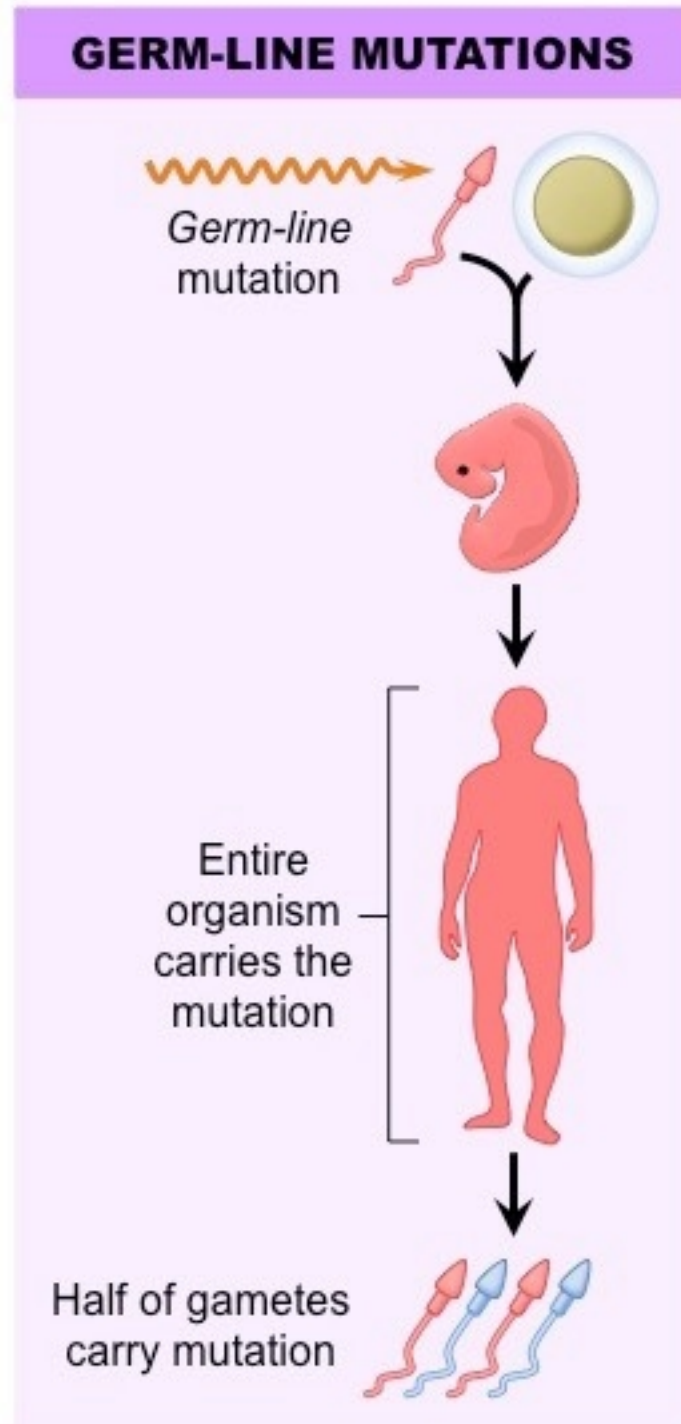
Mutation

Sélection

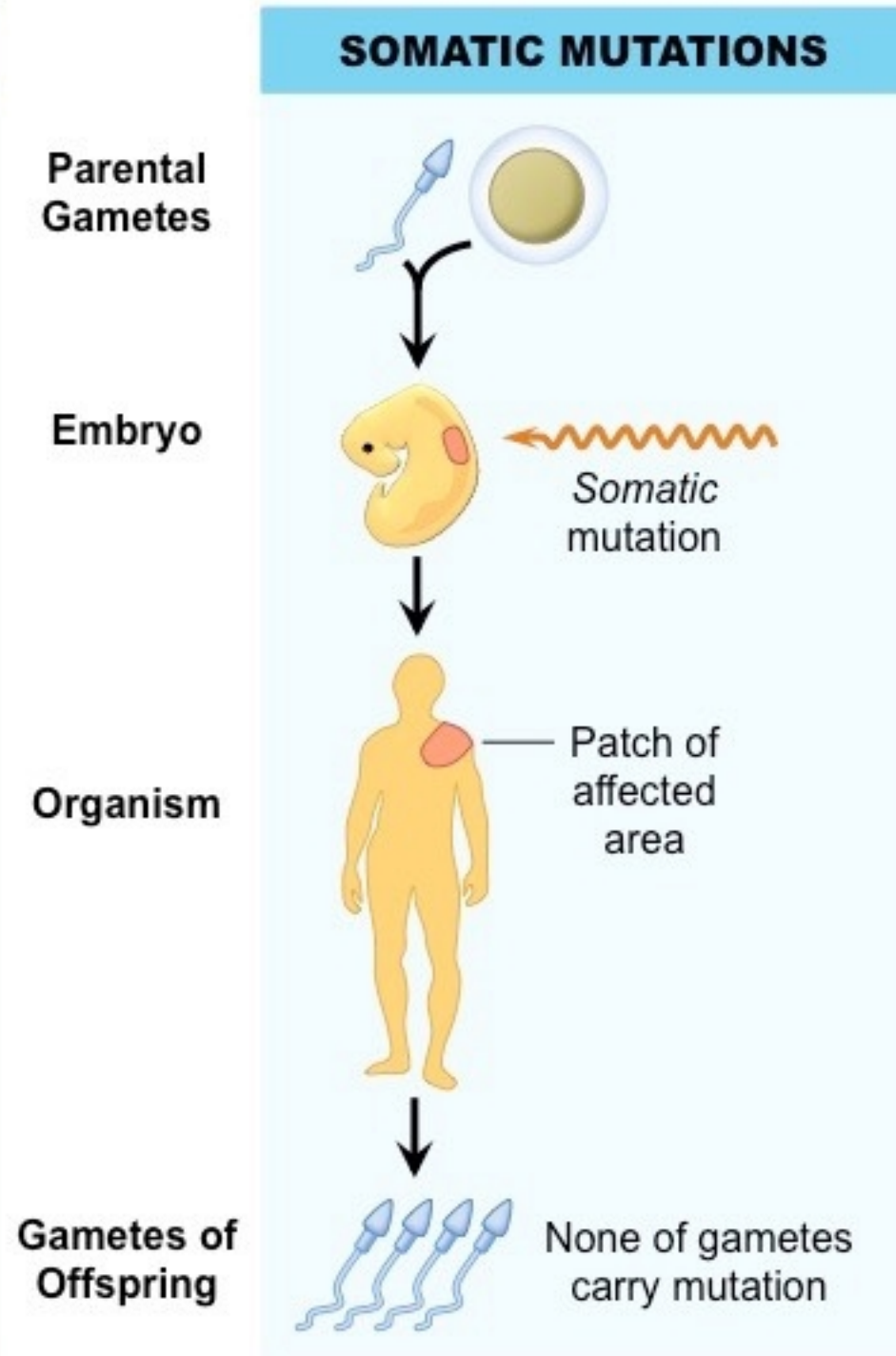
Dérive

Migration

Lignée germinale

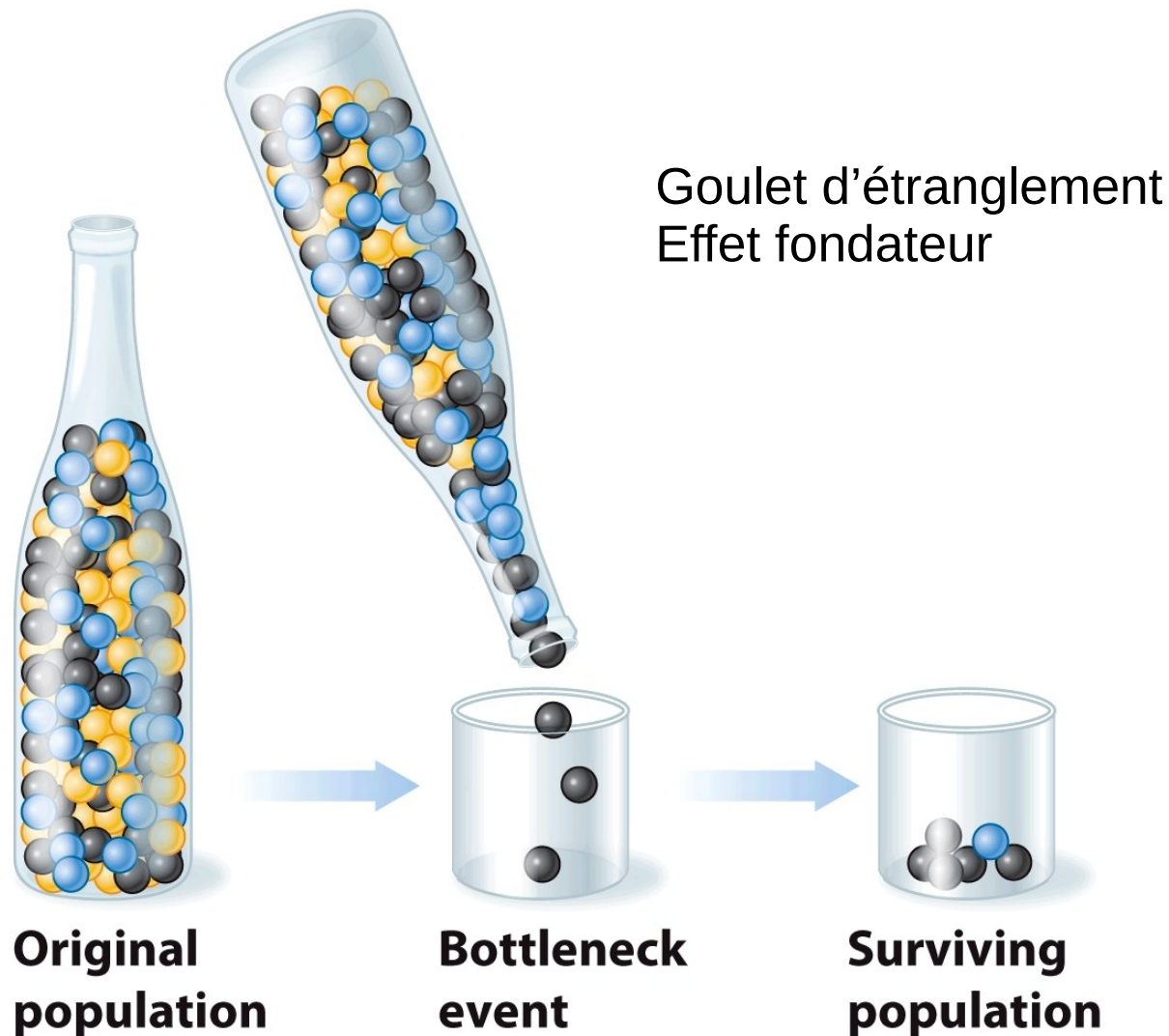


Lignée somatique



Dérive génétique

Fluctuation de la fréquence des allèles au fil des générations dans une population d'effectif limité, liée à l'effet d'échantillonnage, indépendamment des mutations, de la sélection et des migrations.

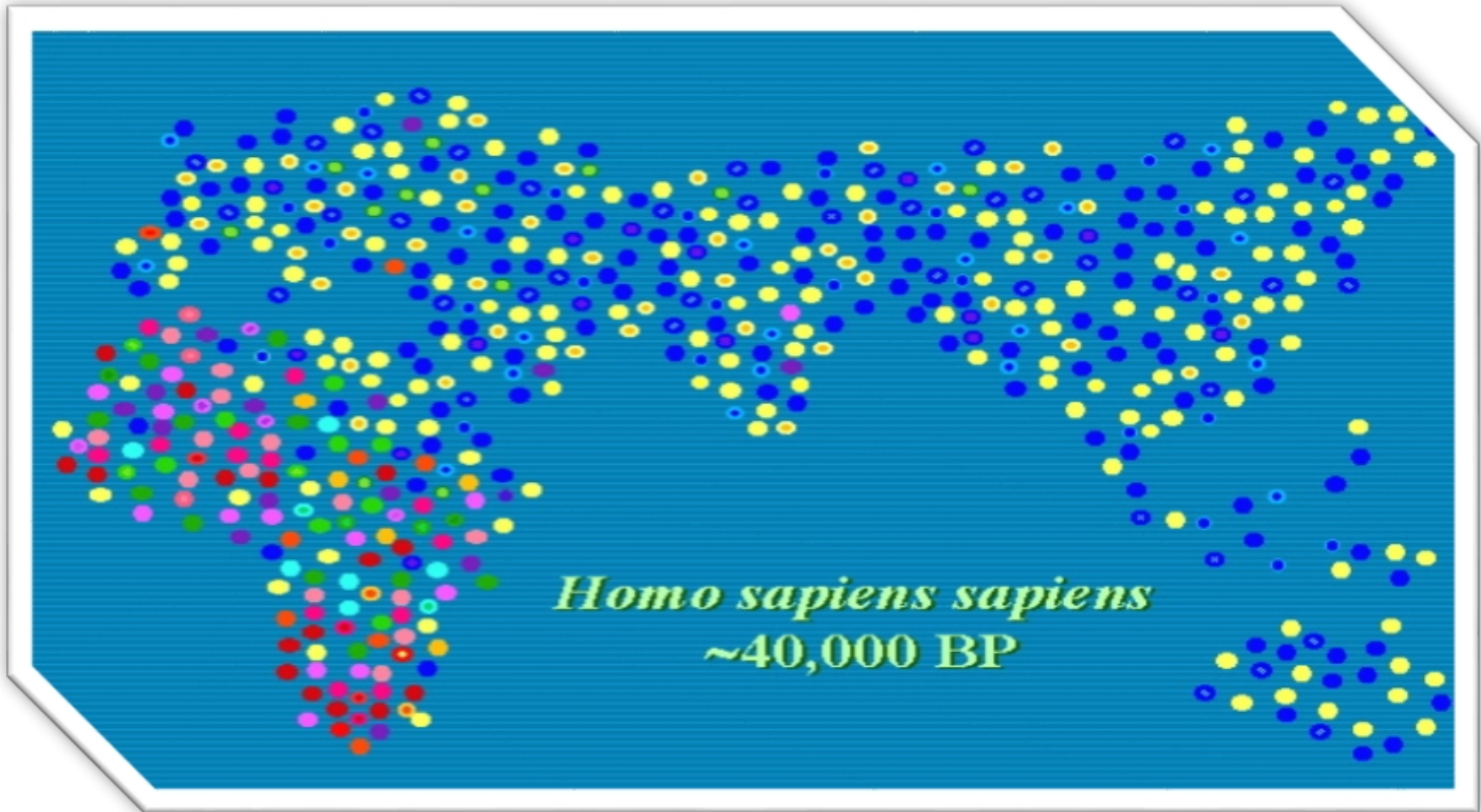


Goulet d'étranglement sur l'atoll de Pingelap (Pacifique)

- 1775 : un typhon a tué toute la population sauf 30 survivants
- 250 personnes actuellement descendants de ces 30 survivants
- 10% de la population souffre d'achromatopsie



Diversité génétique dans l'espèce humaine



Afrique:
Plus grande diversité génétique

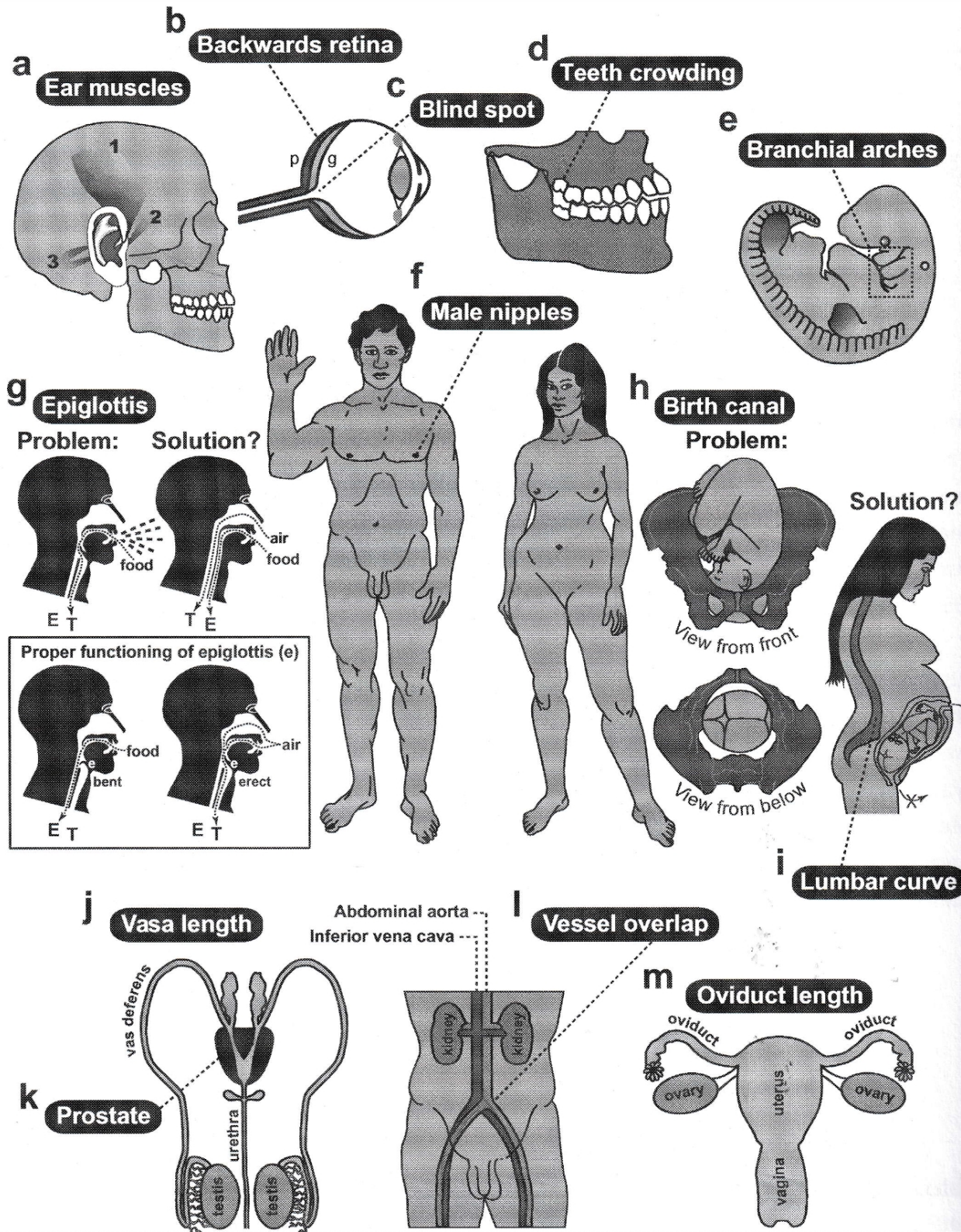
Remarkable cases of evolution



Hypertrichosis. Rare condition, here : Supatra Susphan of Thailand.
Not a true atavism

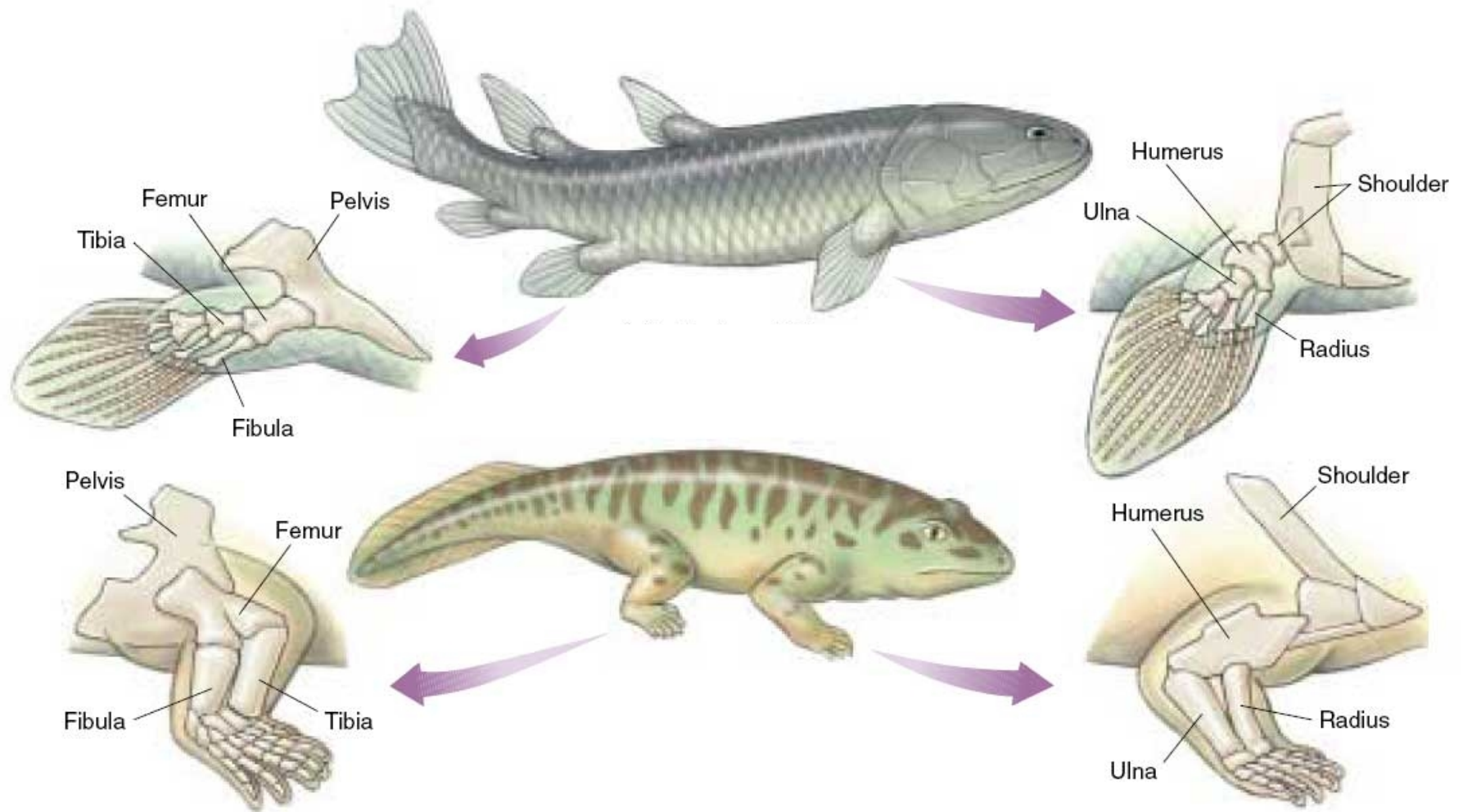
Genetic basis not identified yet

Useless or detrimental traits in humans



Exaptation

Evolution d'un trait de caractère
vers une nouvelle fonction



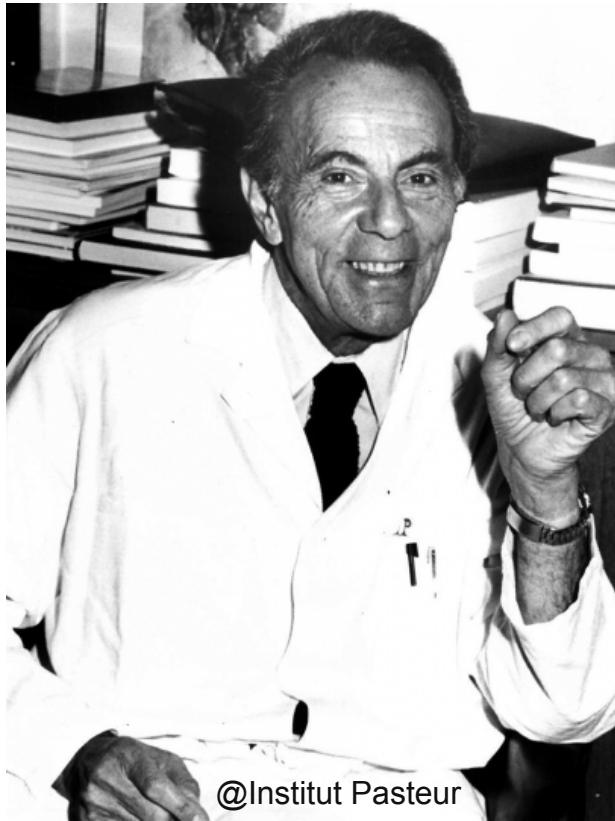
10 June 1977, Volume 196, Number 4295

SCIENCE

Evolution and Tinkering

François Jacob

« La sélection naturelle ne fonctionne pas comme un ingénieur. Elle fonctionne comme un bricoleur. »

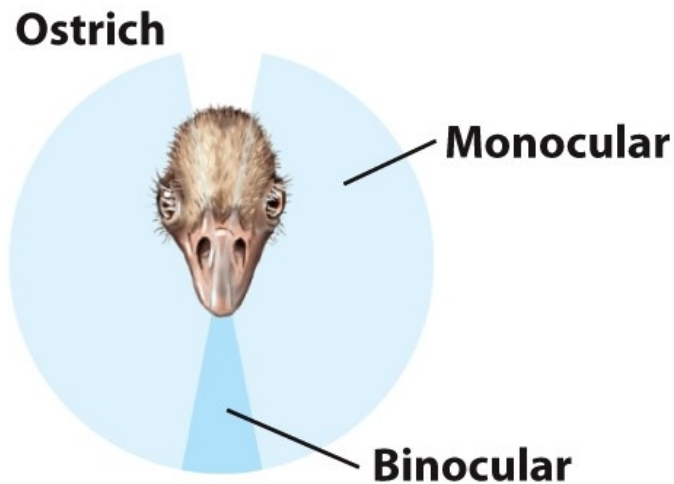
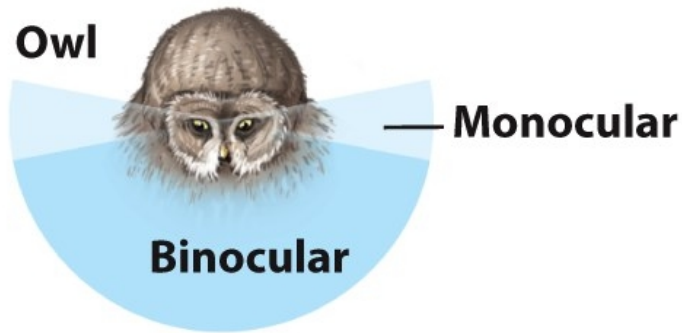
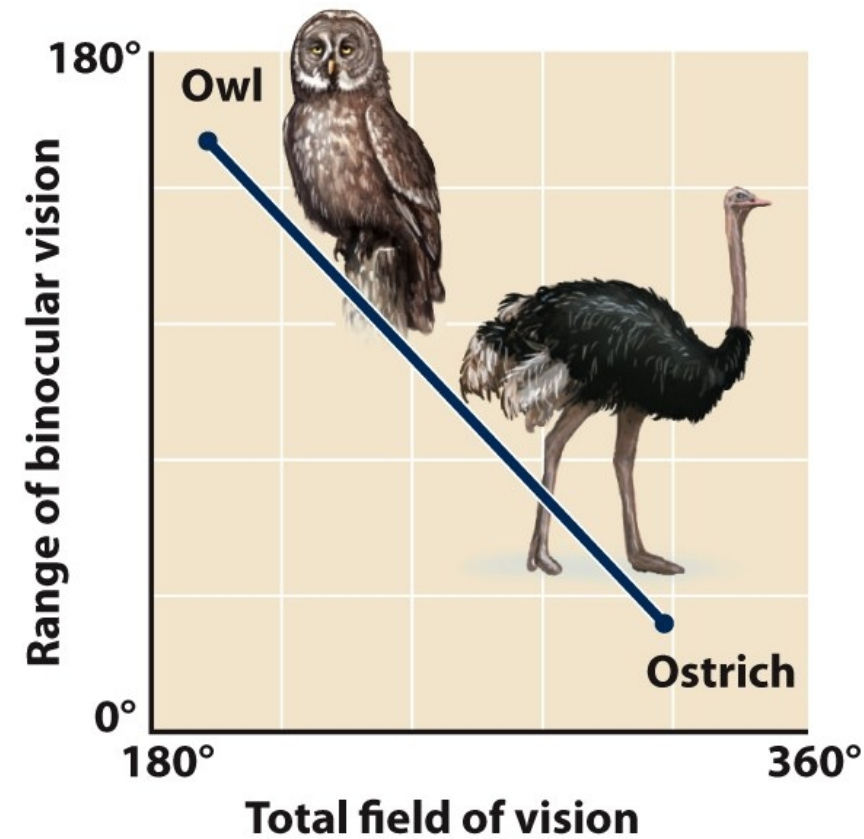


@Institut Pasteur

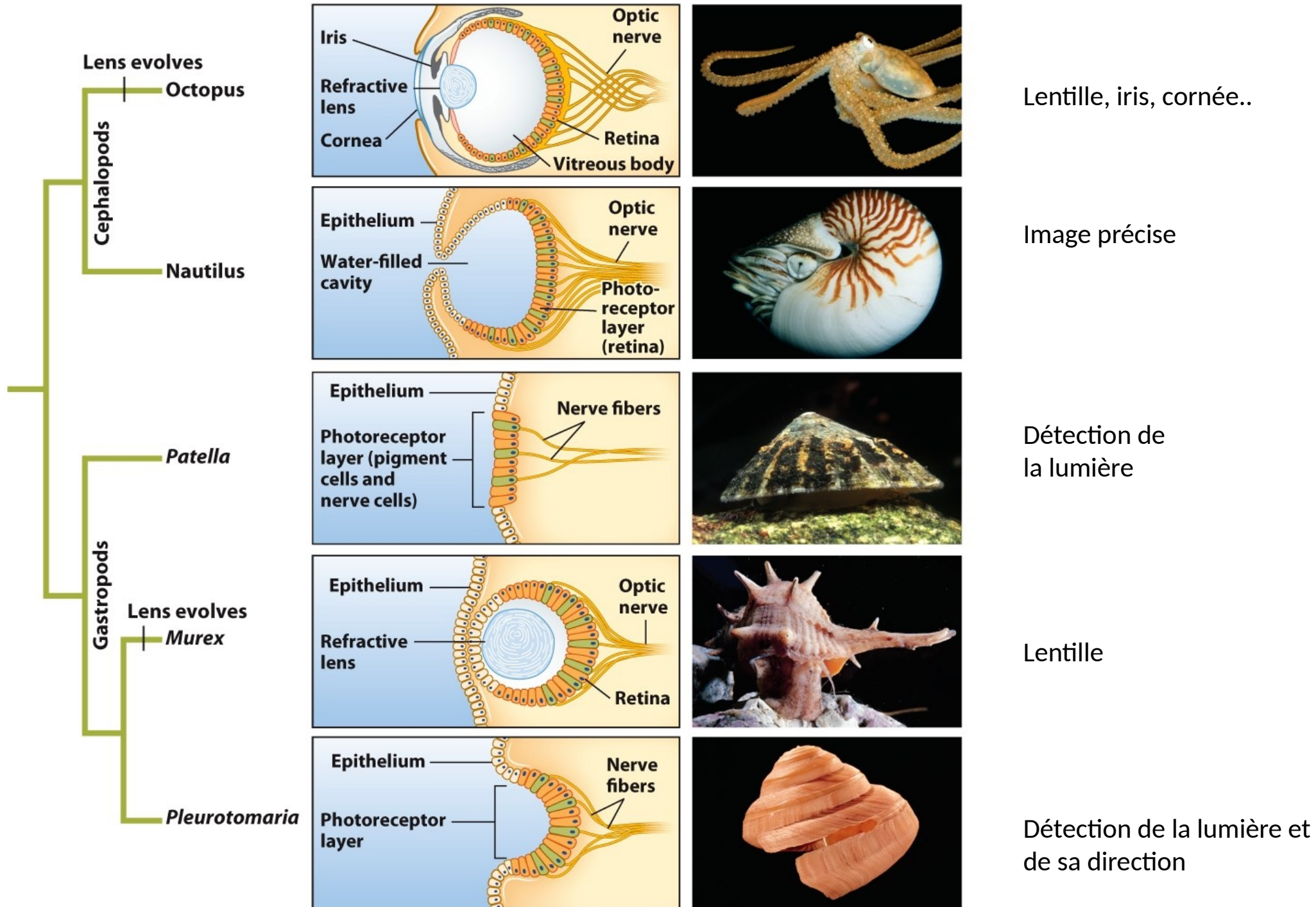
« L'évolution ne tire pas ses nouveautés du néant. Elle travaille sur ce qui existe déjà. [...] La sélection naturelle opère à la manière non d'un ingénieur, mais d'un bricoleur; un bricoleur qui ne sait pas encore ce qu'il va produire, mais récupère tout ce qui lui tombe sous la main. »

(François Jacob, *Le Jeu des possibles*, 1981)

Compromis évolutifs (“trade-offs”)



Adaptation par changements graduels

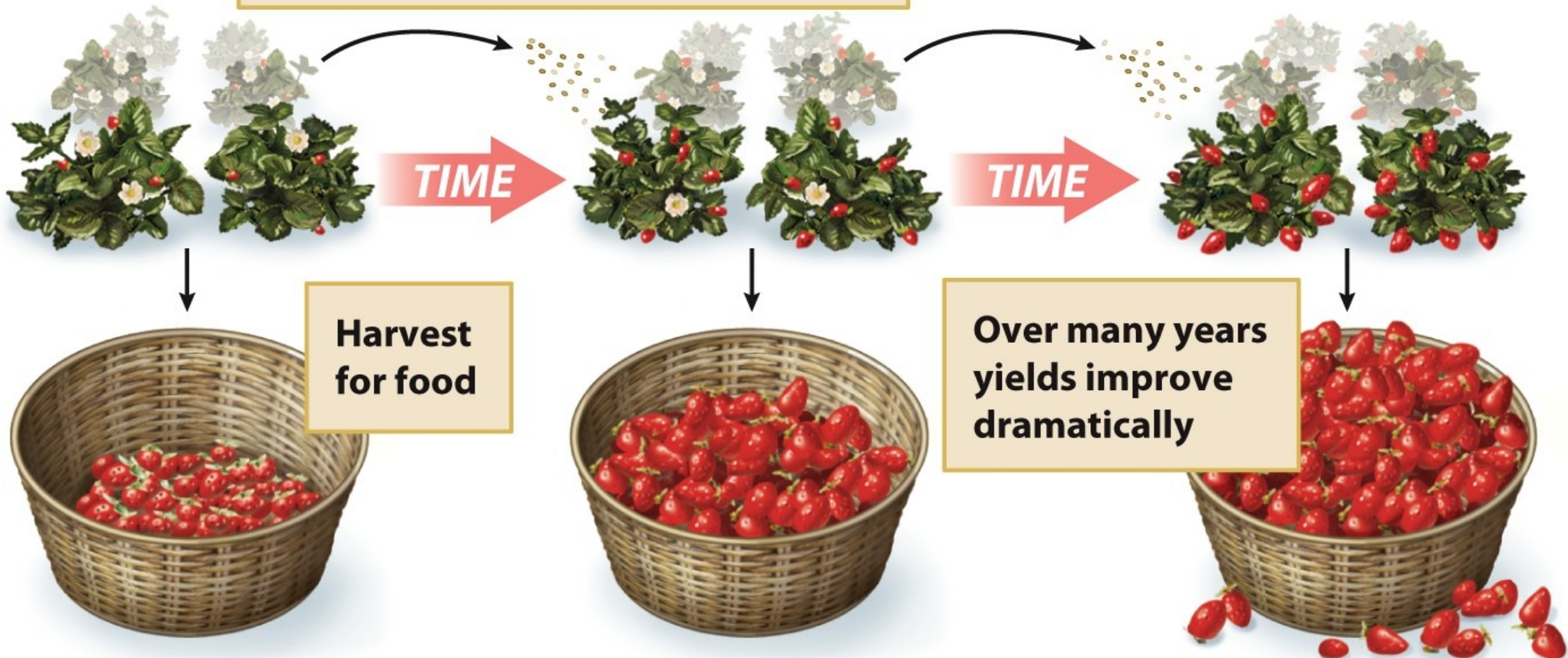


Domestication



Domestication

Plant seeds from the plants that produced the largest, juiciest fruits



Evolution de *Crepis sancta*

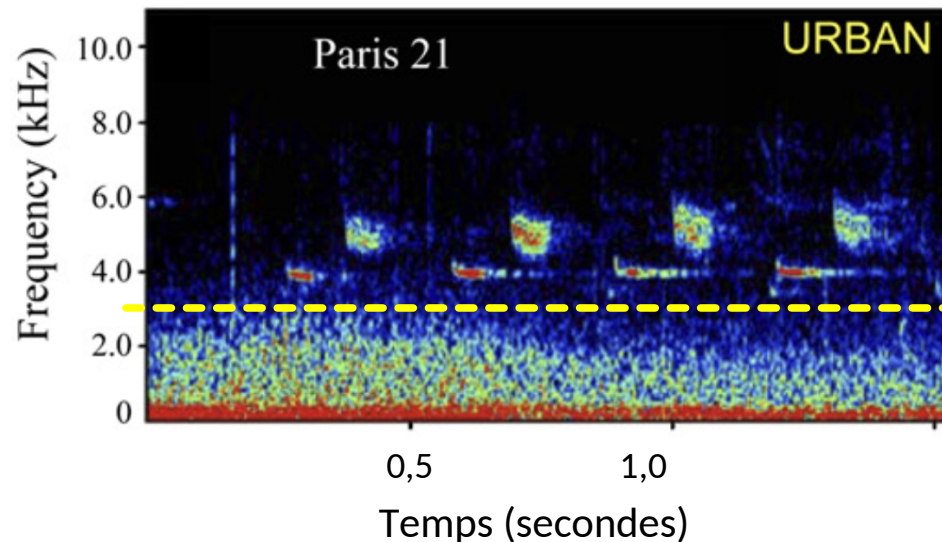


En 5-12 générations

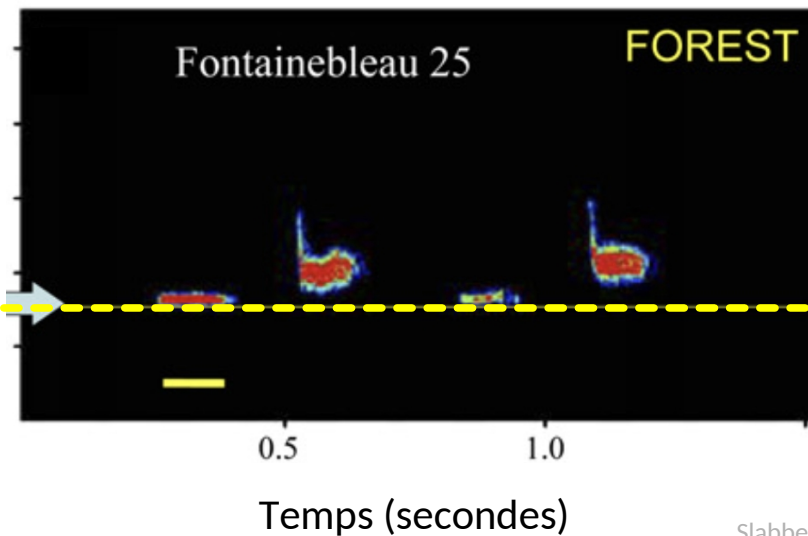
Adaptation de la mésange charbonnière au bruit des villes



Sous la Tour Eiffel



Forêt de Fontainebleau



Retour au sauvage



Mouflon de Corse



Cheval de Przewalski



Chat haret / chat féral

La couleur noire des loups de Yellowstone vient des chiens



© Alexis Rockman

Conclusions

Tous les organismes vivants actuels sont issus d'un ancêtre commun

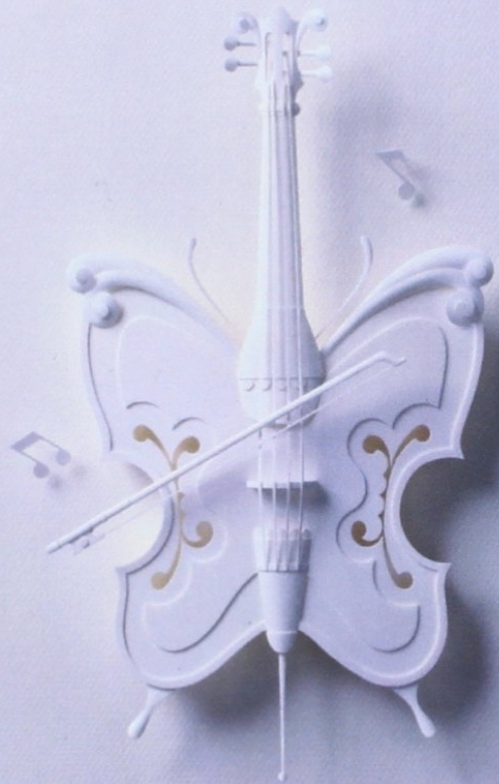
Présence de traces de vie sur Terre depuis près de 4 milliards d'années

Théorie de l'évolution : 3 piliers, 4 forces

Bricolage de l'évolution

Evolution toujours en cours aujourd'hui pour toutes les espèces

The MUSIC of LIFE



Biology Beyond Genes

Denis Noble

'Essential and pleasurable for any thinking person' Steven Pinker

DANIEL C. DENNETT

DARWIN'S DANGEROUS IDEA

Evolution and the
Meanings of Life

