

## Evolution de la biosphère pendant les 4 premiers d'années

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EVOLUTION DE LA MATIÈRE ET DE LA VIE  
SRSL

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### Comment reconstruire l'histoire de la vie?

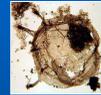
- Géologie-Biologie
  - Environnement
  - Traces de vie

→ Les quatre premiers milliards d'années



$\delta^{13}\text{C}$





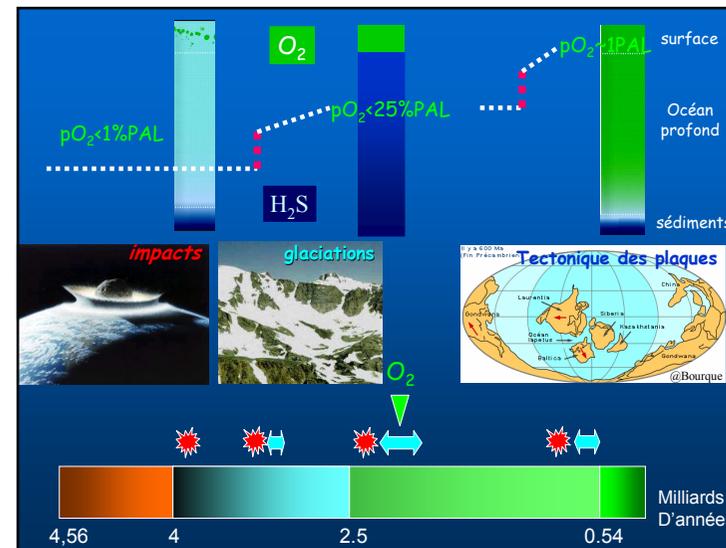
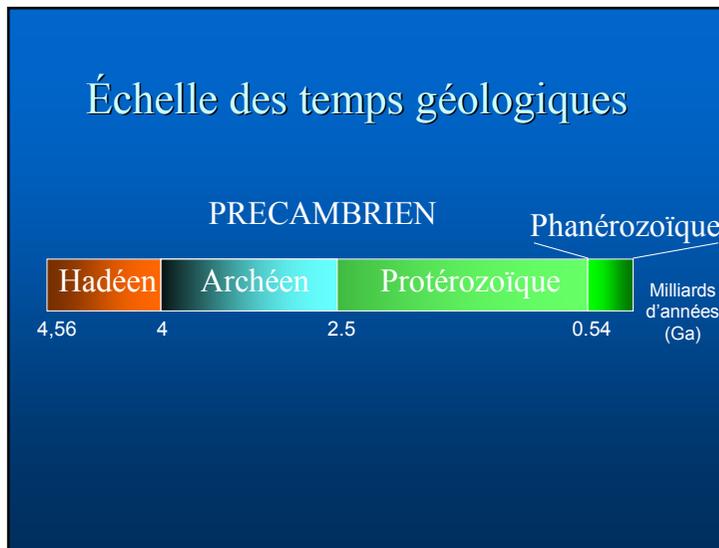
$\delta^{34}\text{S}$



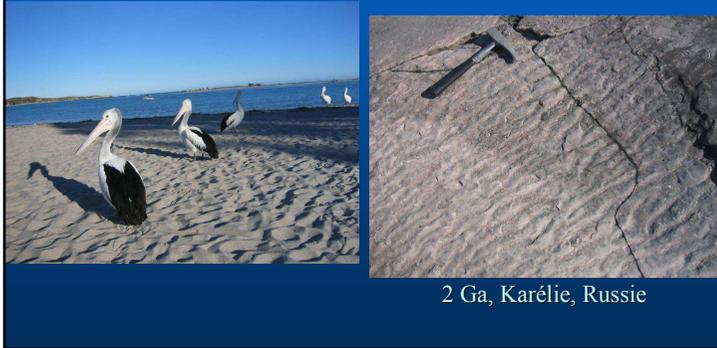




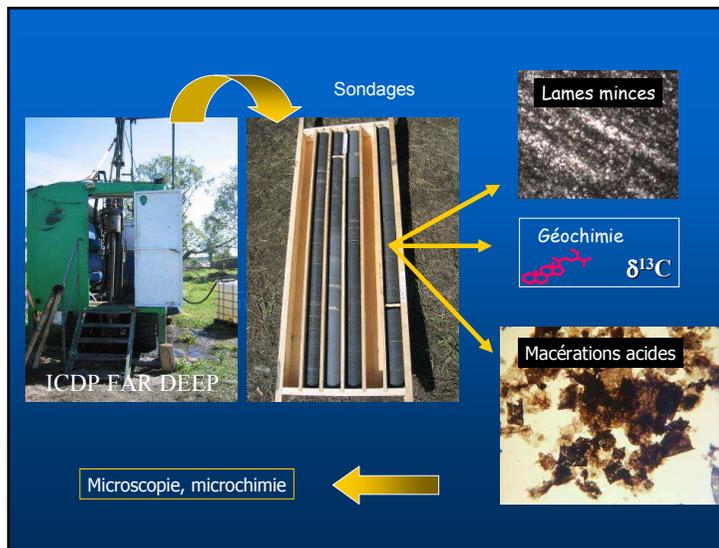
©Friedman



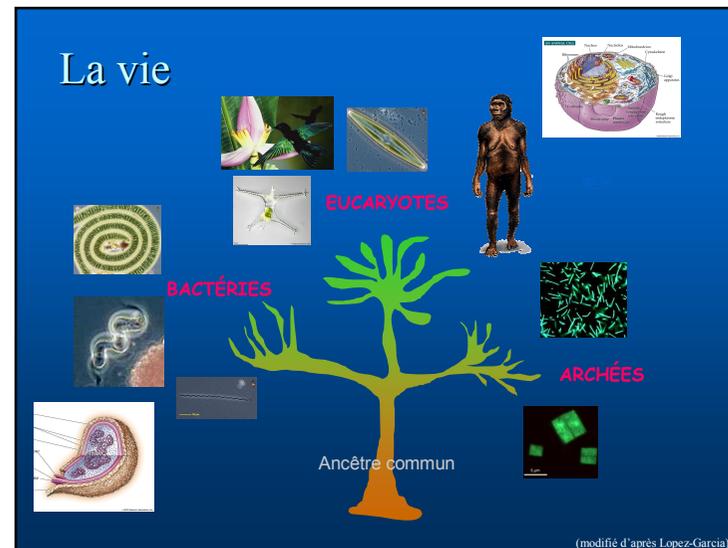
Le présent est (souvent) la clef du passé



~1.9 Ga Ludikovien, Karélie, Russie



La vie



### Quelles traces de vie dans le Précambrien?

- Isotopes de C, S, N, Fe
- Biomarqueurs
- Structures biosédimentaires
- Fossiles

### Traces isotopiques de la vie

$^{12}\text{C}$  (99%) (6 p+, 6n<sup>0</sup>),  $^{13}\text{C}$  (7n<sup>0</sup>),  $^{14}\text{C}$  (8n<sup>0</sup>)

CaCO<sub>3</sub> CH<sub>2</sub>O

*fractionnement*

$\delta^{13}\text{C}$

$^{12}\text{C}$   $^{13}\text{C}$   $^{12}\text{C}$   $^{13}\text{C}$

(modifié de Knoll, 2003)

### Biomarqueurs: molécules fossiles

Bacterium

Membrane

Hopanepolyol

@MIT

### Biomarqueurs: molécules fossiles

Water column

Sediment

Hopanepolyol

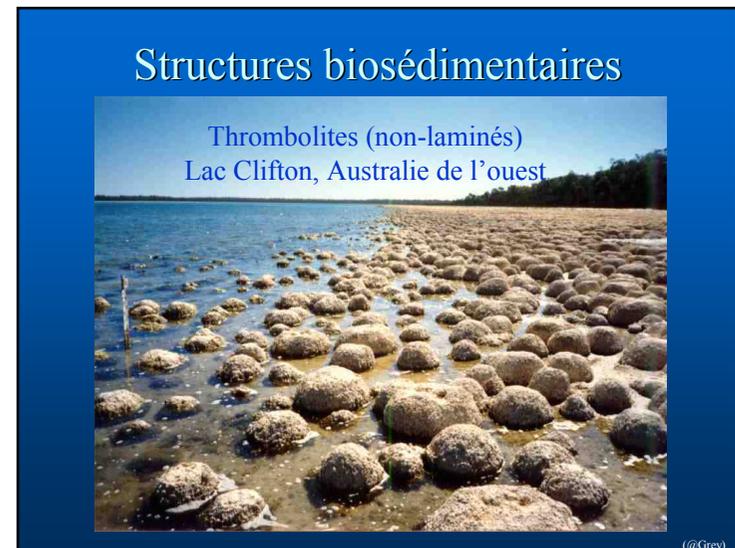
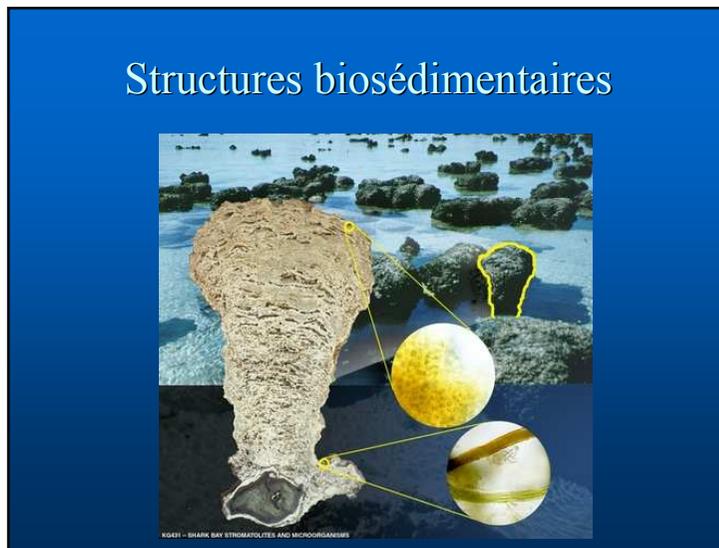
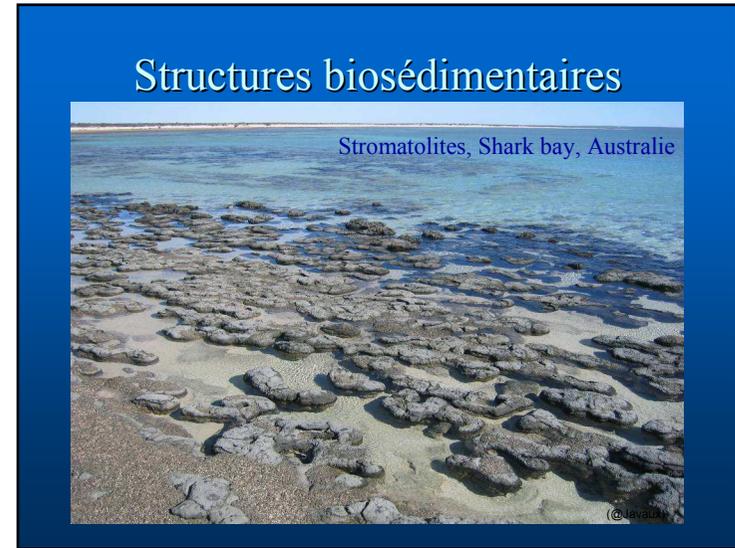
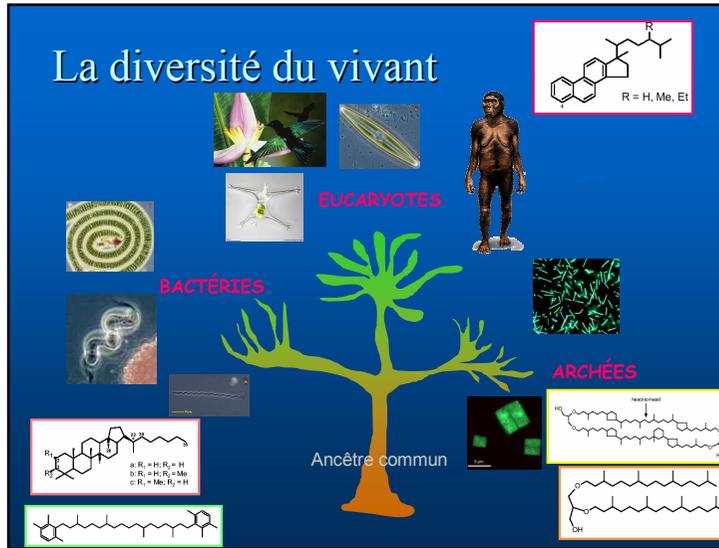
Biolipid

Diagenesis

Hopane

Molecular fossil Biomarker

@MIT



### Structures biosédimentaires

Tapiss microbiens

This slide features four photographs of microbial mats. The top-left image is a close-up of a mat with a distinct layered structure, credited to @cyanosite. The top-right image shows a mat in a coastal or tidal environment, credited to @Javaux. The bottom-left image shows a vibrant red mat, credited to @RobSkold. The bottom-right image shows a mat on a rocky shore, credited to @Javaux.

### Fossiles: micro et macro

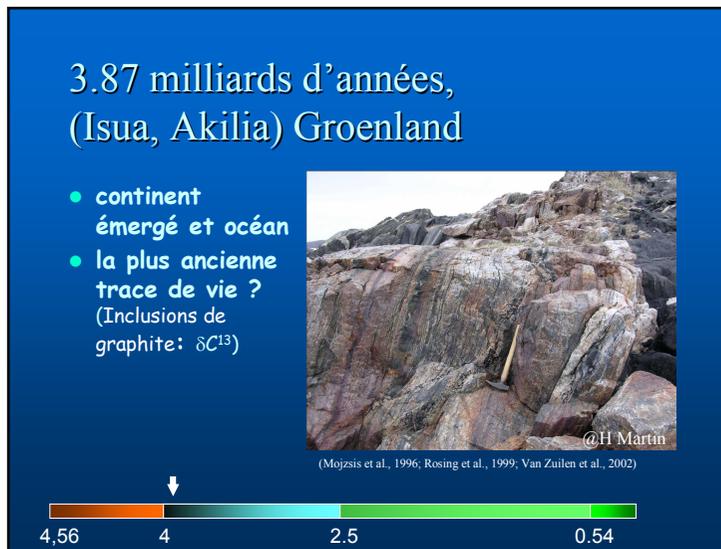
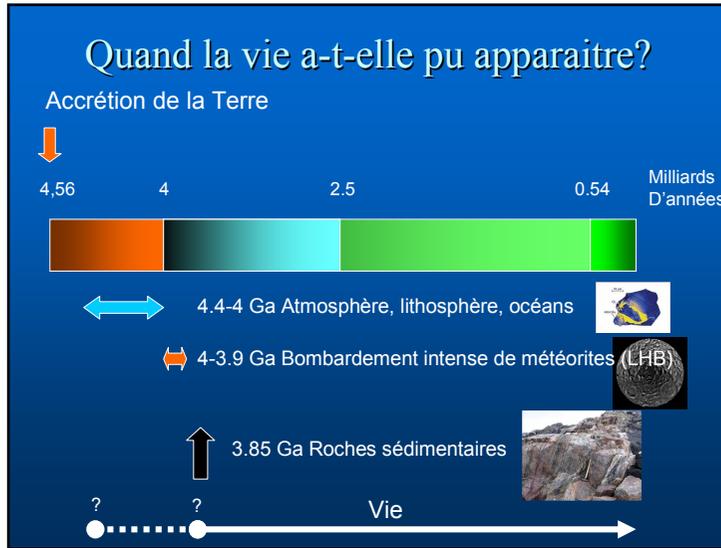
This slide is a collage of fossil images. It includes a microfossil being examined under a microscope, a fossilized shell, a spiral fossil, and a fossilized organism. Credits include (Garcia-Ruiz et al, 2003) and (@Knoll, Butterfield, Porter, Javaux).

### De la vie partout! Quelles traces de vie?

This slide contains six photographs. The top row shows a rocky coastline, a blue mineral deposit, and a red salt flat. The bottom row shows an underwater scene, a beach, and a rocky shore. Credits include (@Dale Andersen, 1996) and (@Javaux).

### 4,567 milliards d'années Naissance du système solaire

This slide features two diagrams illustrating the formation of the solar system. The left diagram shows the protoplanetary disk stage, credited to @ Brandeas Univ. The right diagram shows the resulting planetary system, credited to @ JPL/NASA.



### Microfossiles

- 3,465 Ga Apex Chert, Australie
- les plus vieux fossiles ou pseudo-fossiles?



Schopf and Packer, 1987; Schopf et al., 2002    Brasier et al., 2002; Lindsay et al., 2005

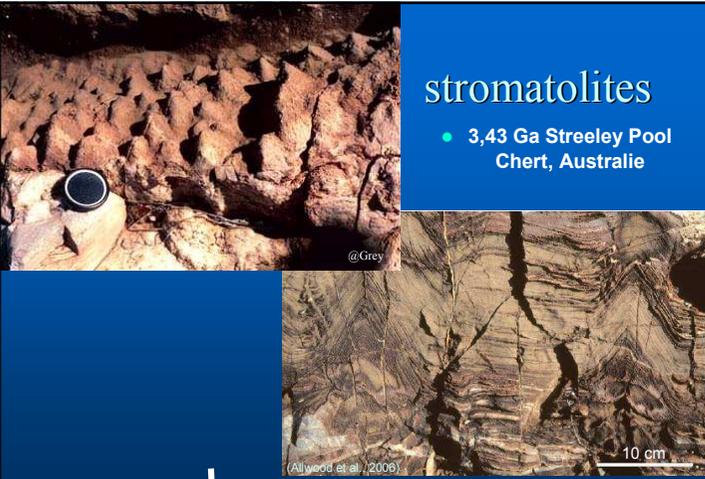
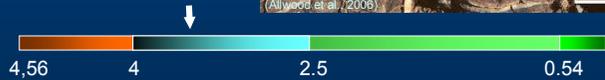
- Milieu marin peu profond
- Morphologie et chimie biologiques
- Probablement cyanobactéries

- Milieu hydrothermal métallifère sous fond marin
- Morphologie et chimie abiotiques

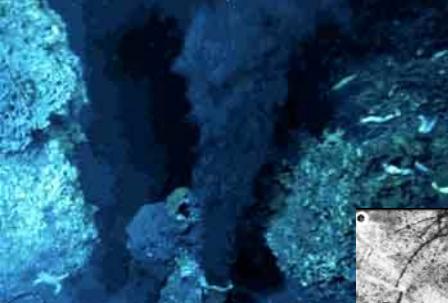


### stromatolites

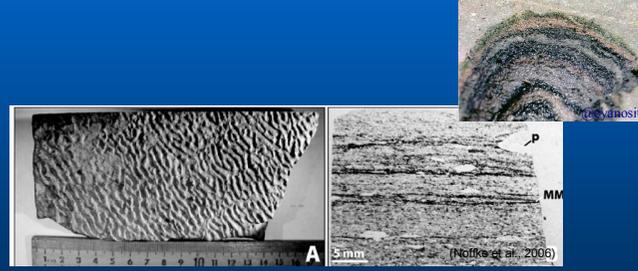
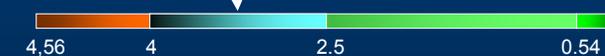
- 3,43 Ga Streeley Pool Chert, Australie

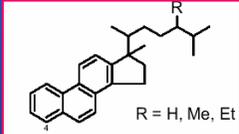
### 3.2 milliards d'années: la vie au chaud!?

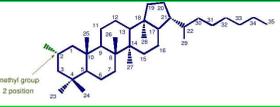



### 3.2-2.9 milliards d'années: des tapis bactériens battus par les marées (Barberton, Afrique du Sud)

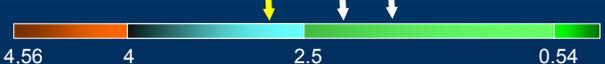
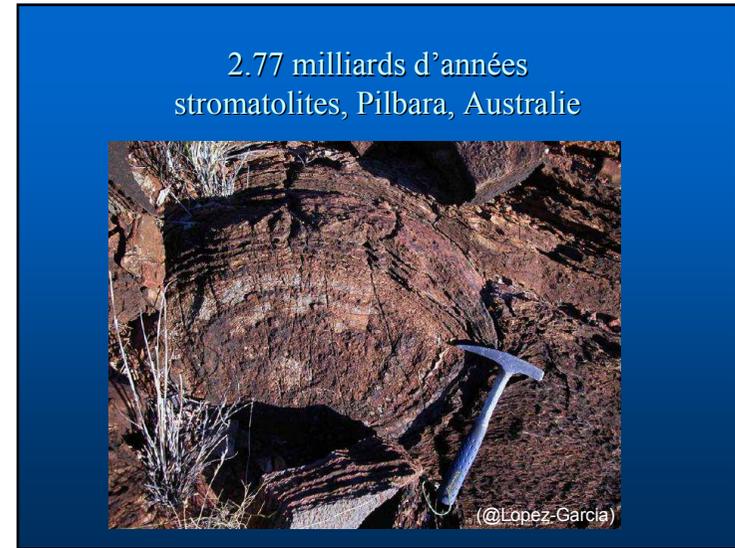



Molécules fossiles  
 de (?) 2.77 milliards d'années  
 Australie (mais...)

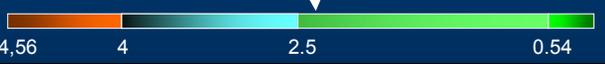



Brocks et al., 1999;  
 Summons @geobiology.mit.edu  
 Rasmussen et al., 2008

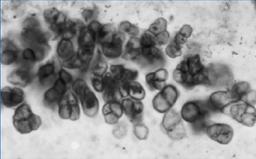



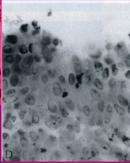
Oxygène! « red beds »  
 dunes éoliennes, Karélie, 2.2 Ga

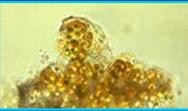



(@Javaux)

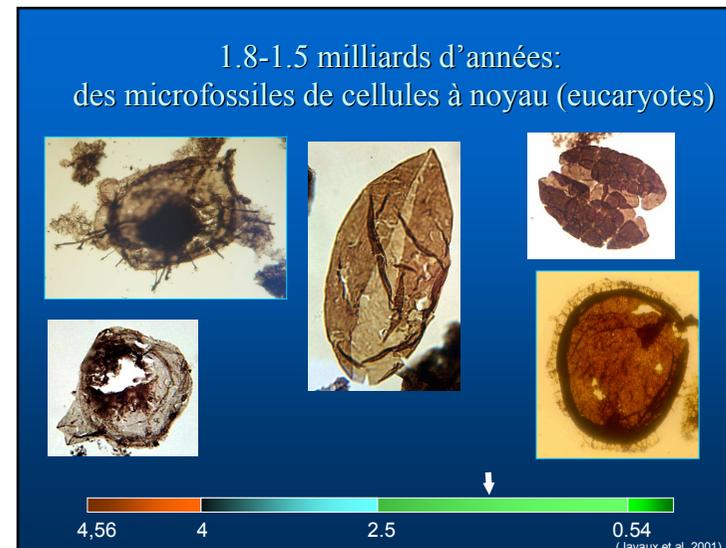
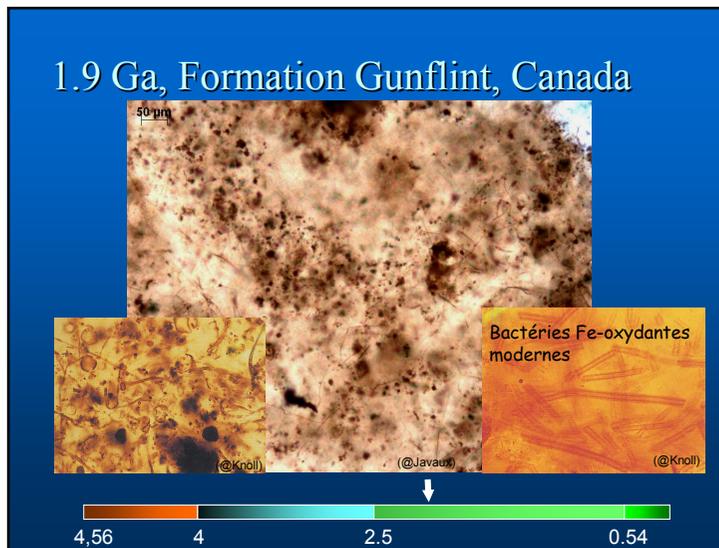
Pas d'oxygène sans cyanobactéries:  
 microfossiles depuis 2.1 milliards d'années

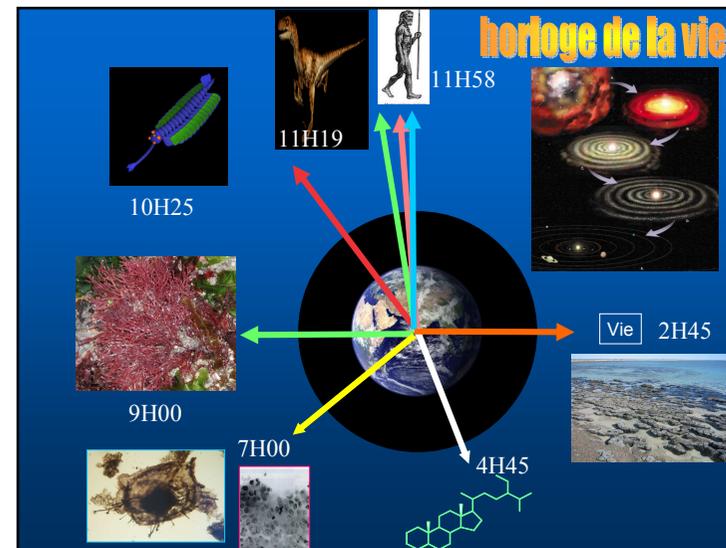
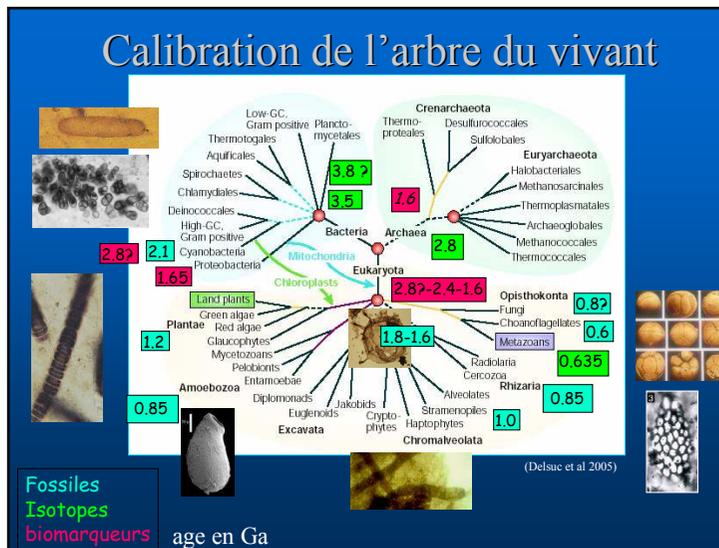
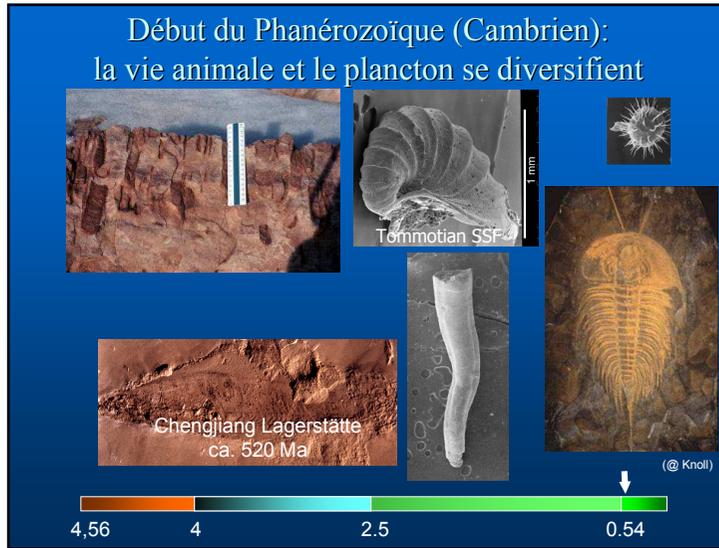


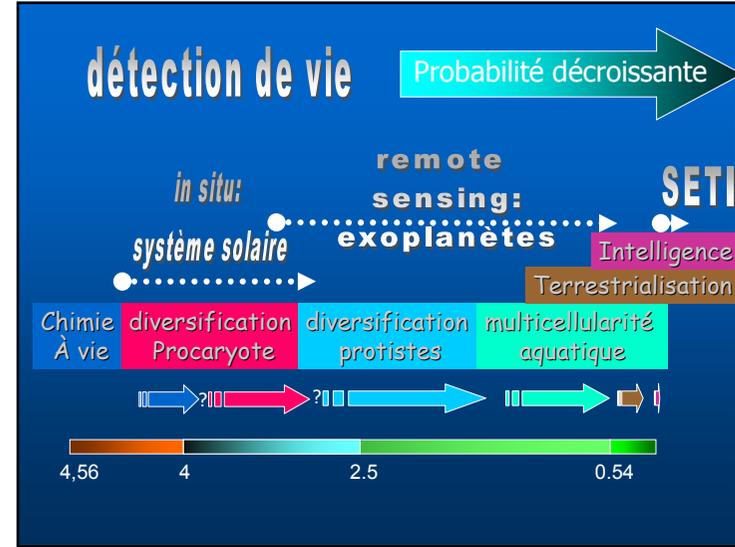
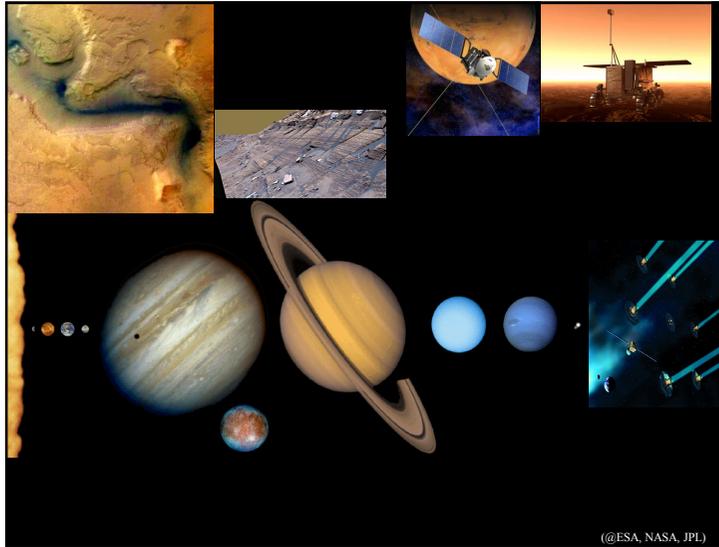


(@Kool 2003)









### Propriétés de la vie

- Ordre
- Information (matériel génétique)
- Reproduction cellulaire
- Croissance et développement
- Réponse à l'environnement
- Évolution Darwinienne

→ Chaque propriété est nécessaire mais pas suffisante seule