

Voyage vers Mars: Aspects médicaux et biologiques

Augusto Cogoli

Zero-g LifeTec  *GmbH*

4^{es} Journées nationales suisses sur la Stérilisation:
Protection de l'environnement et stérilisation

Fribourg

11 – 12 juin 2008



Fondé en 1976: unité de
recherche de l'EPF Zurich
www.spacebiol.ethz.ch



Fondé en 2000: Biotechnology
Space Support Center, pour le
soutien de projets dans la Station
spatiale internationale.
Partenariat: ESA, EPFZ, SSO.



Fondé en 2004: entreprise spin-off
de l'EPF Zurich
www.zeroglifetec.ethz.ch

**Astronaute
Bruce
McCandless**

1984



SOMMAIRE

- 1. Effets physiologiques du vol spatial sur l'être humain**
- 2. La mission Mars**
- 3. Soins hygiéniques et médicaux**
- 4. Recyclage des déchets**
- 5. Perspectives / visions**

1. Effets physiologiques du vol spatial sur l'être humain

**Déplacement des
fluides corporels
vers la tête**

```
graph TD; A([Déplacement des fluides corporels vers la tête]) --> B[Volume accru de liquide dans la tête et le haut du corps]; B --> C[Vertige]; B --> D[Excrétion accrue d'urine];
```

**Volume accru
de liquide
dans la tête et le
haut du corps**

Vertige

**Excrétion
accrue
d'urine**



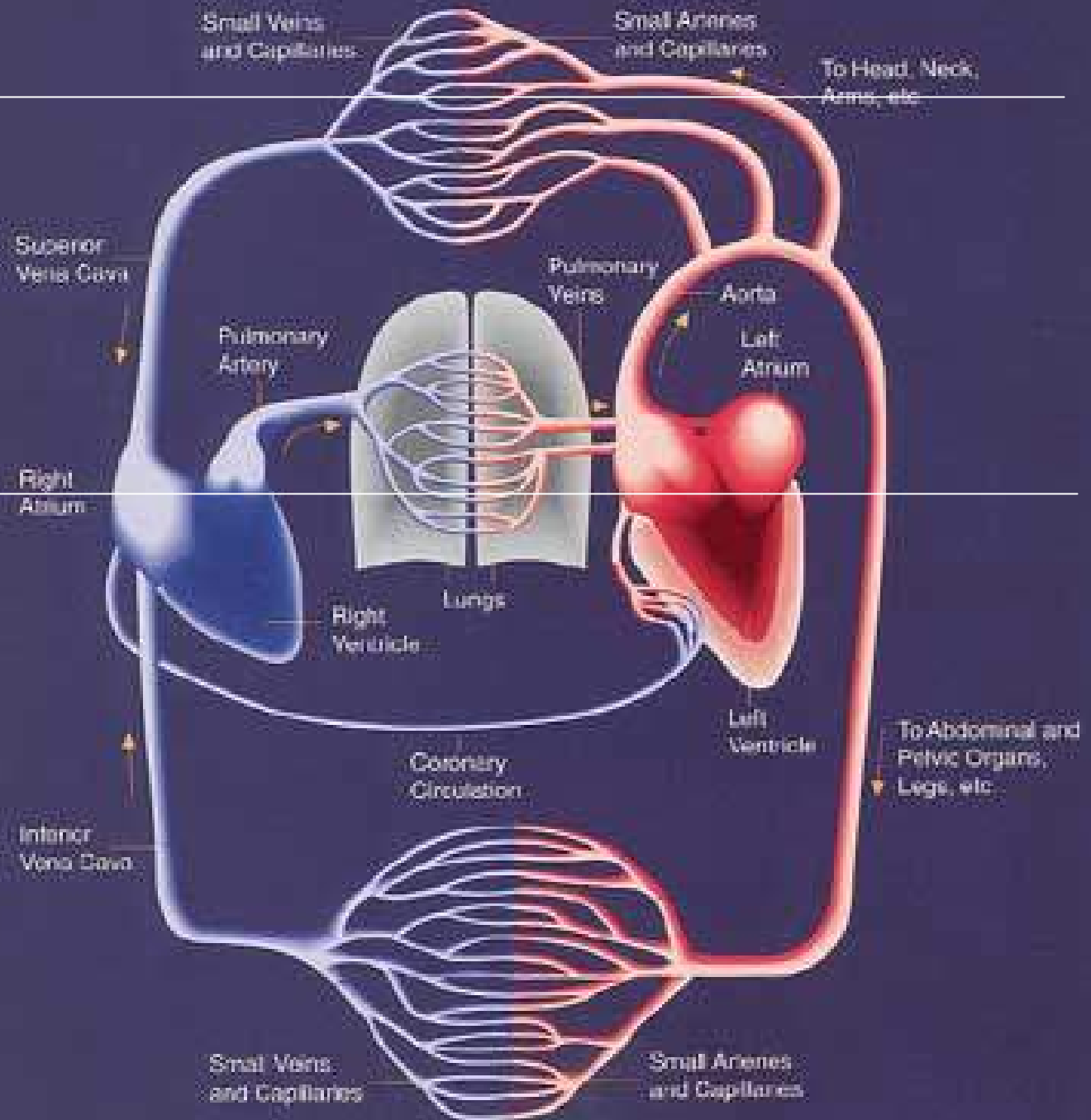
Jim Bagian

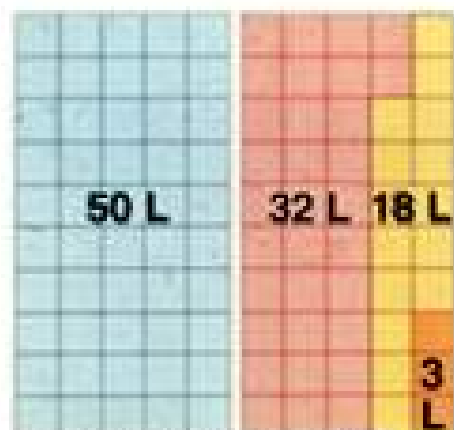


60 mm Hg

100 mm Hg

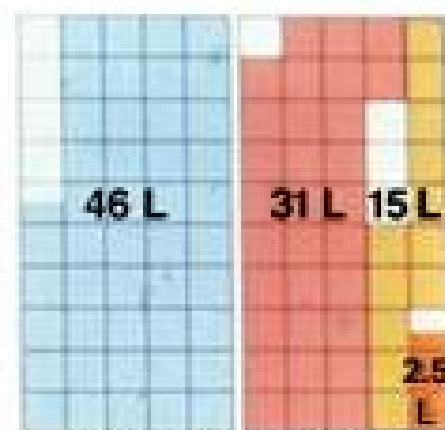
180 mm Hg





PREFLIGHT

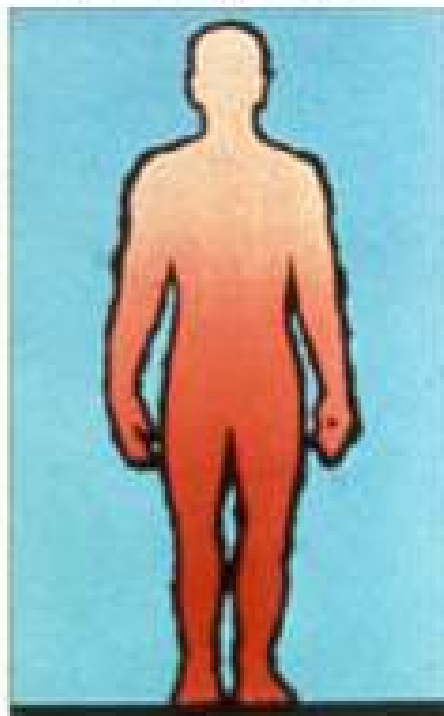
- TOTAL BODY WATER
- INTRACELLULAR FLUID
- EXTRACELLULAR FLUID
- PLASMA VOLUME



REENTRY

WEIGHTLESSNESS

BLOOD DISTRIBUTION



**Suppression
du poids du corps**

```
graph TD; A([Suppression du poids du corps]) --> B[Atrophie musculaire]; A --> C[Atrophie osseuse, ostéoporose];
```

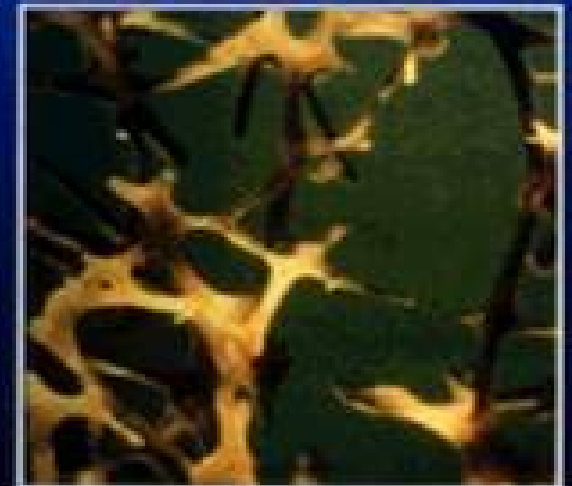
A flowchart with a purple oval at the top containing the text 'Suppression du poids du corps'. Two yellow arrows point from the bottom of the oval to two green rectangular boxes below. The left box contains the text 'Atrophie musculaire' and the right box contains the text 'Atrophie osseuse, ostéoporose'.

**Atrophie
musculaire**

**Atrophie
osseuse,
ostéoporose**

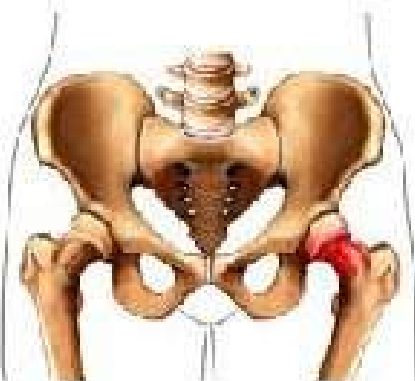
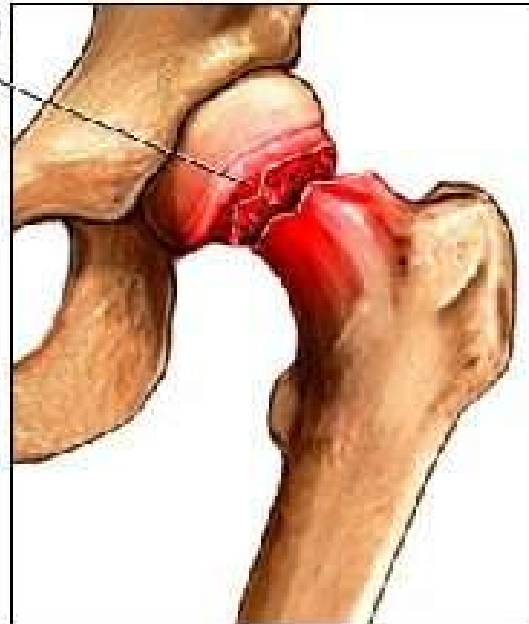


(A) Normal bone

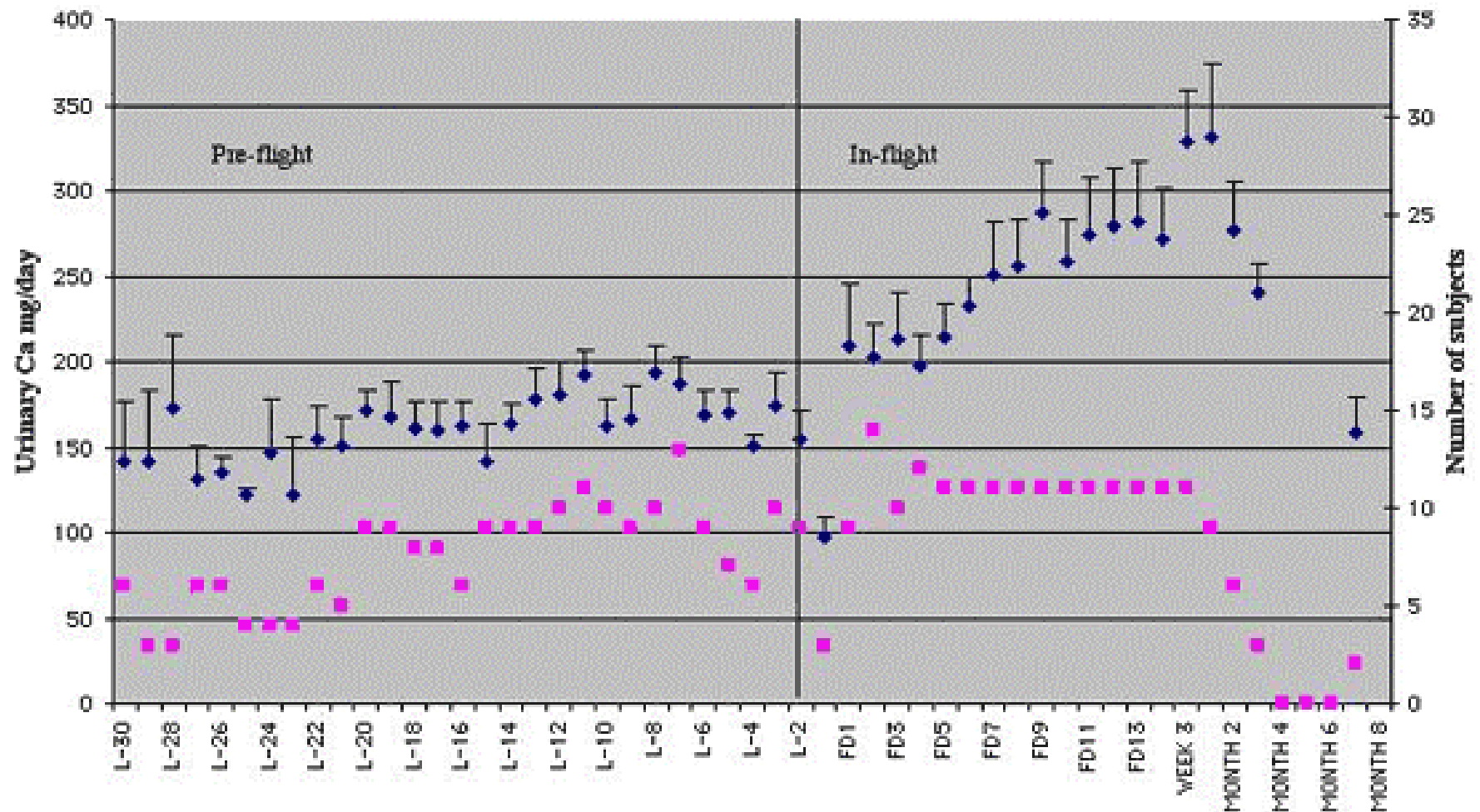


(B) Osteoporotic bone

Fracture of the
hip bone



Mean Urinary Calcium in Space

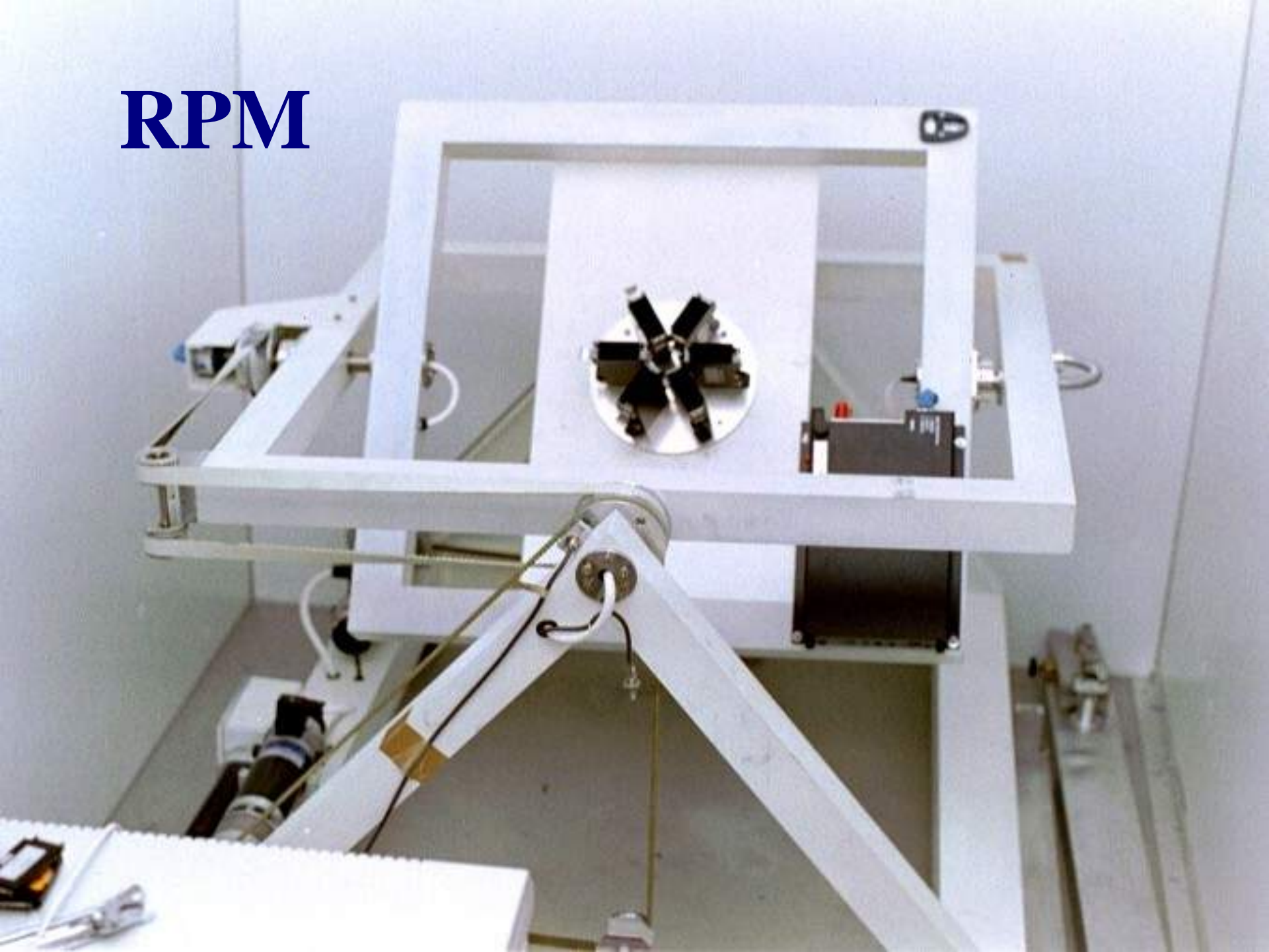


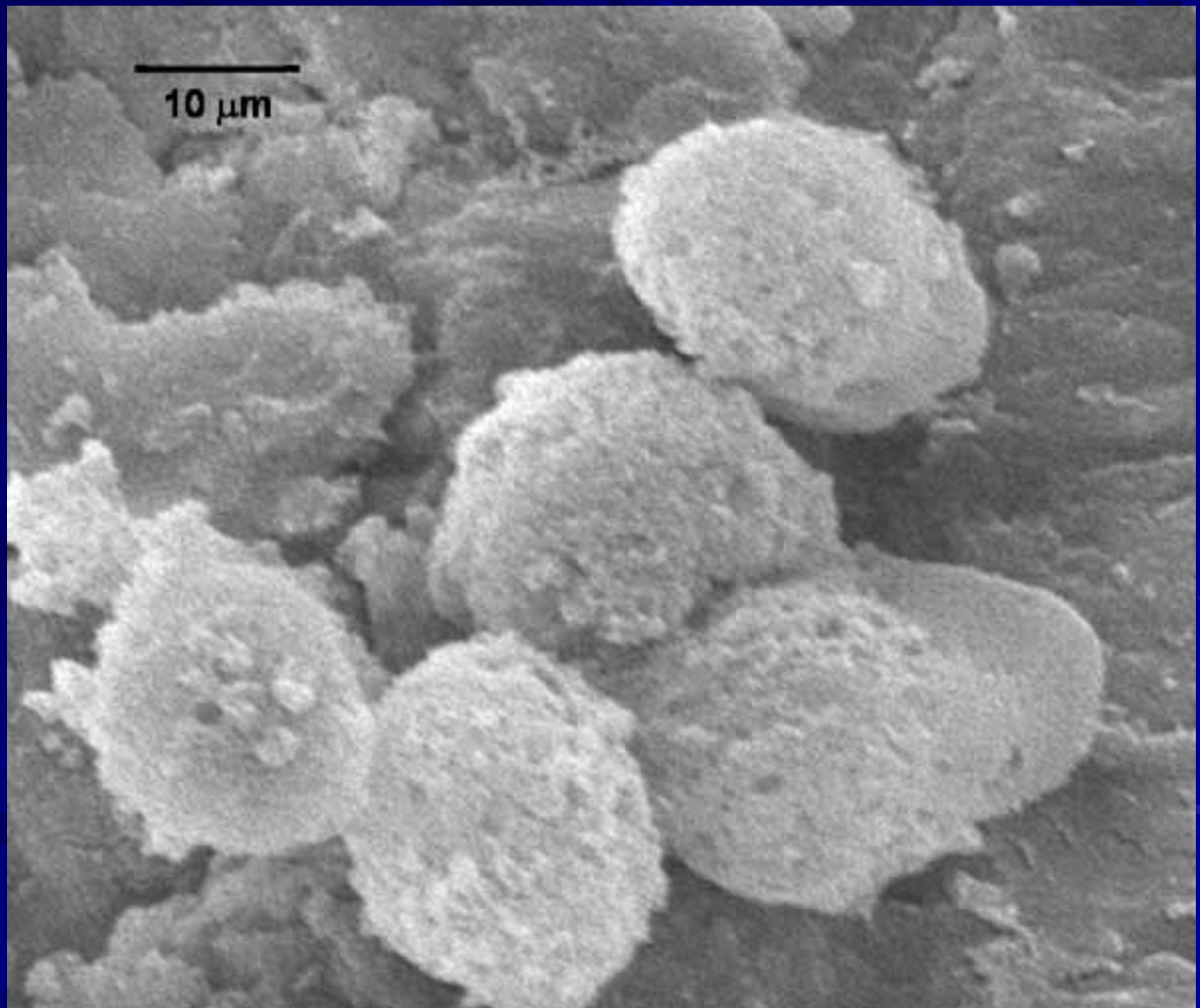
1. Compiled from Data in the Life Sciences Data Archive
2. Data from missions Gemini VII, Skylab 2-4, Shuttle, Salyut 7, Soyuz 9.
3. Life Sciences Data Archive does not independently verify results
4. L- means launch minus x days, FD means flight day

◆ Mean Urinary Calcium ■ Number of subjects

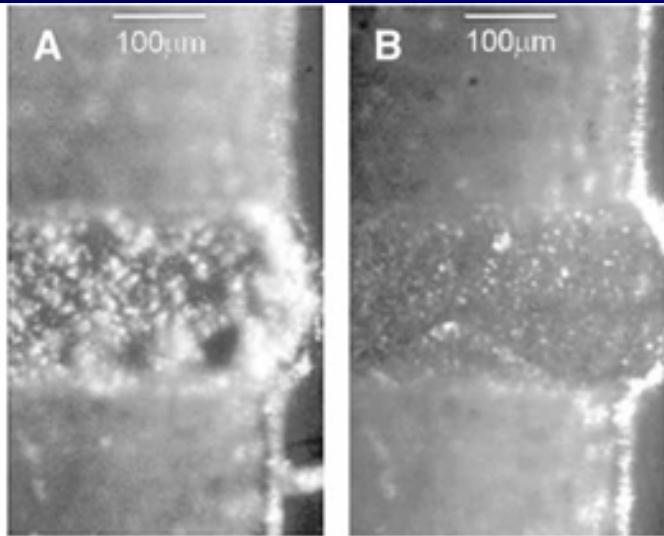


RPM

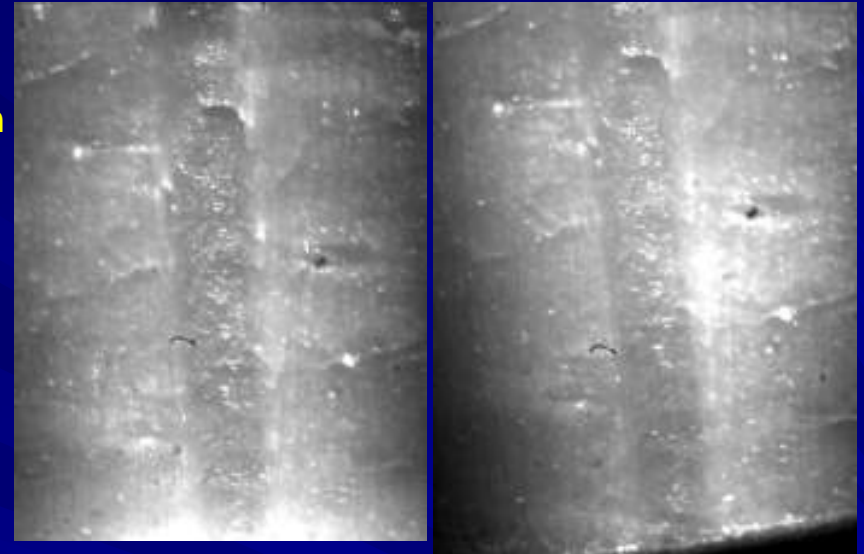




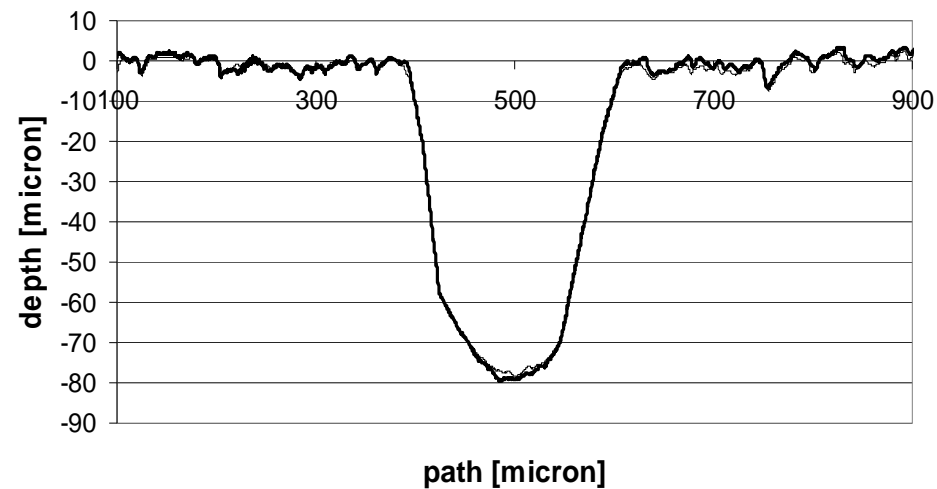
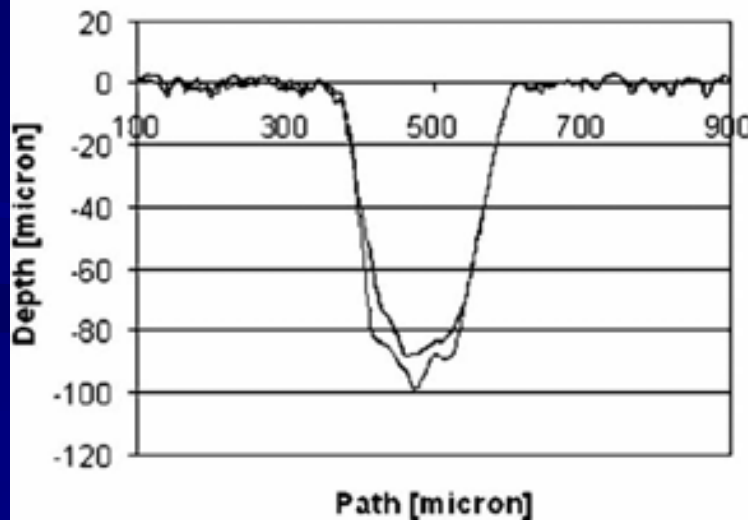
0 g simulation, 72h
avant après



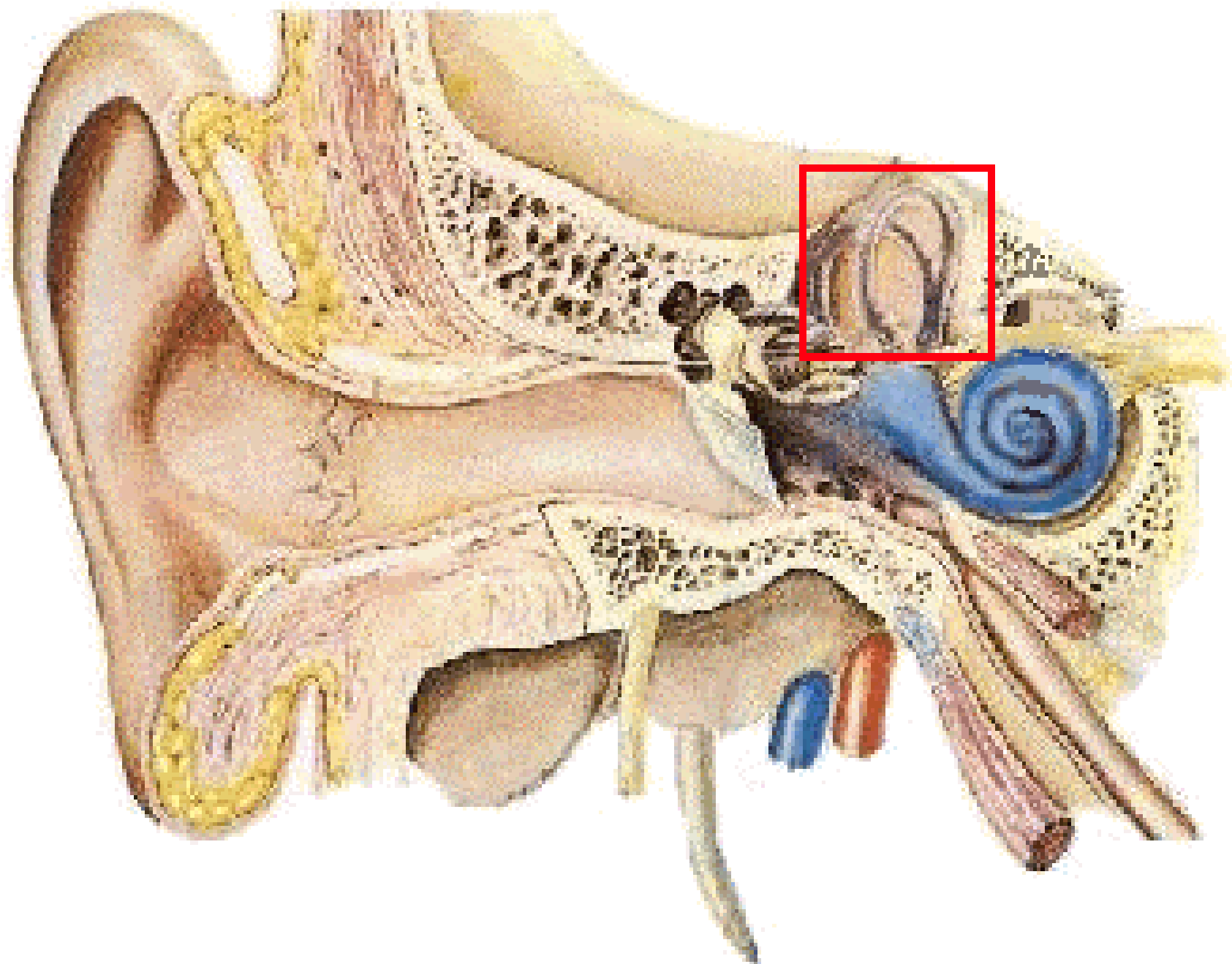
1 g contrôle, 72h
avant après

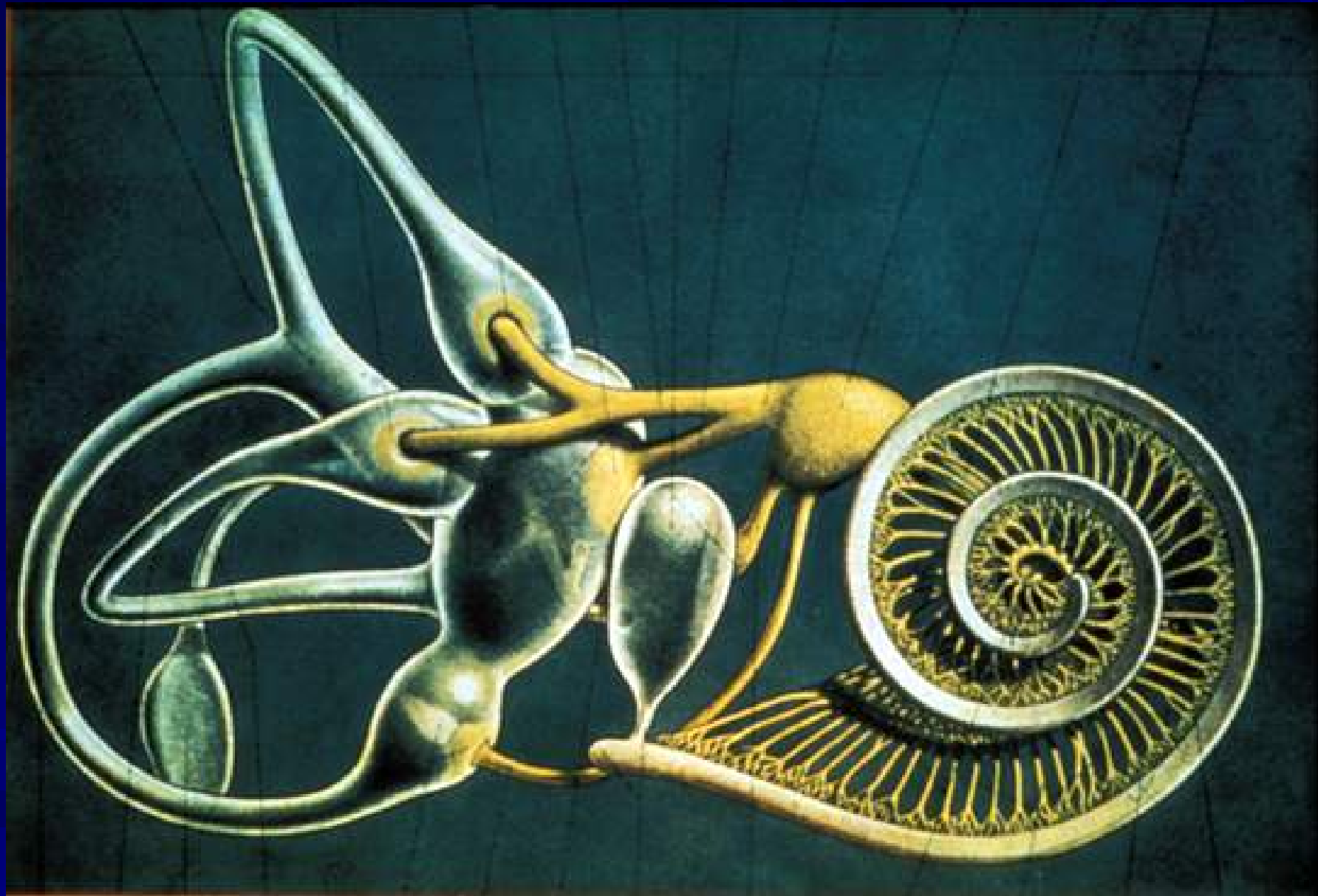


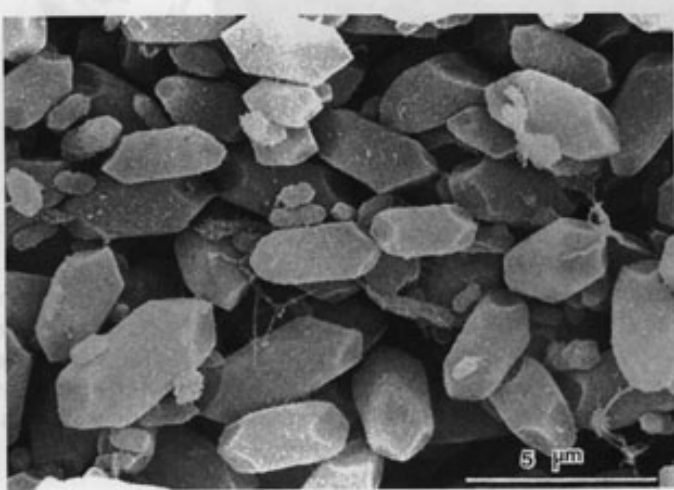
100 μm



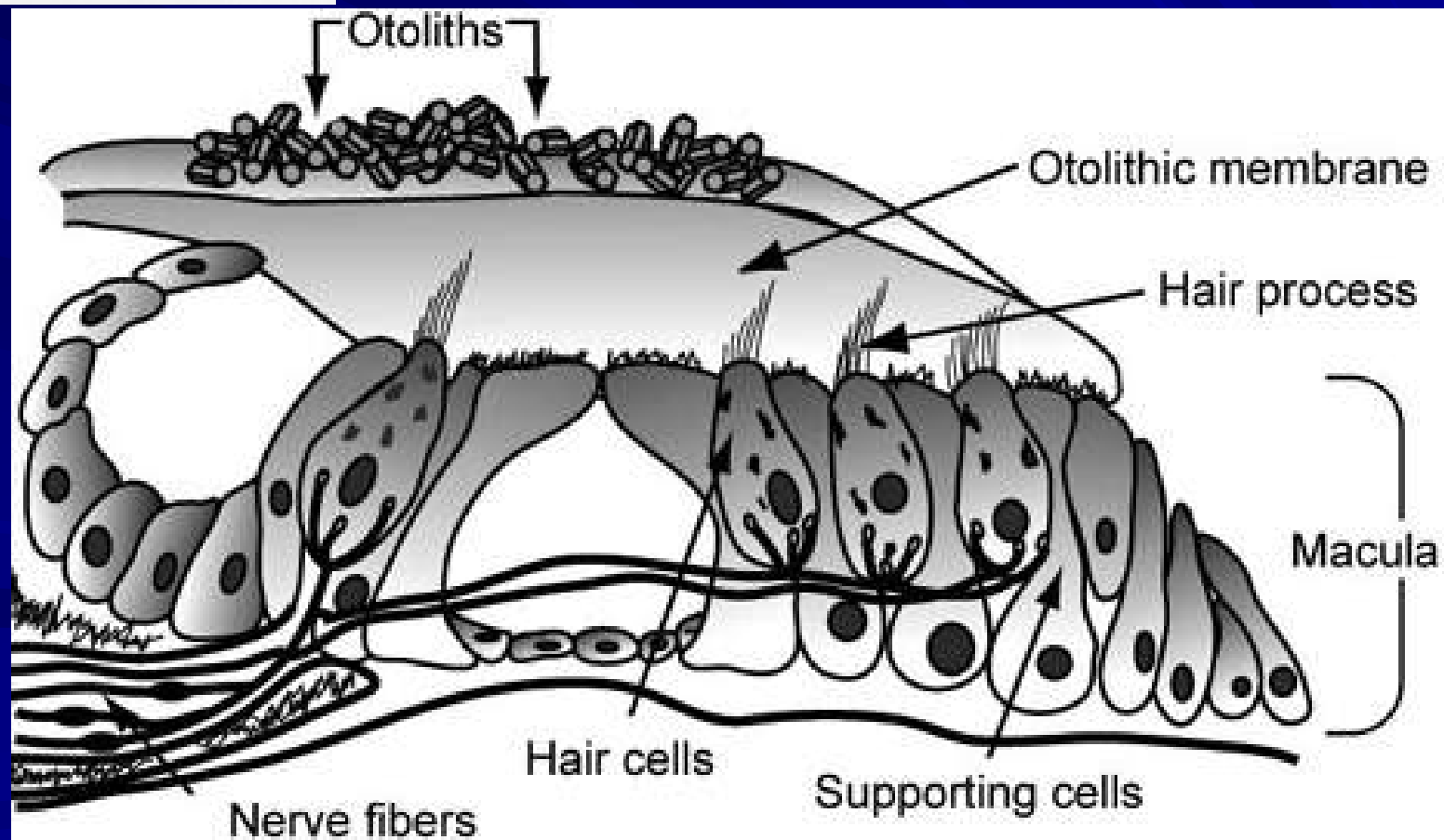
**« Mal de
l'espace »**

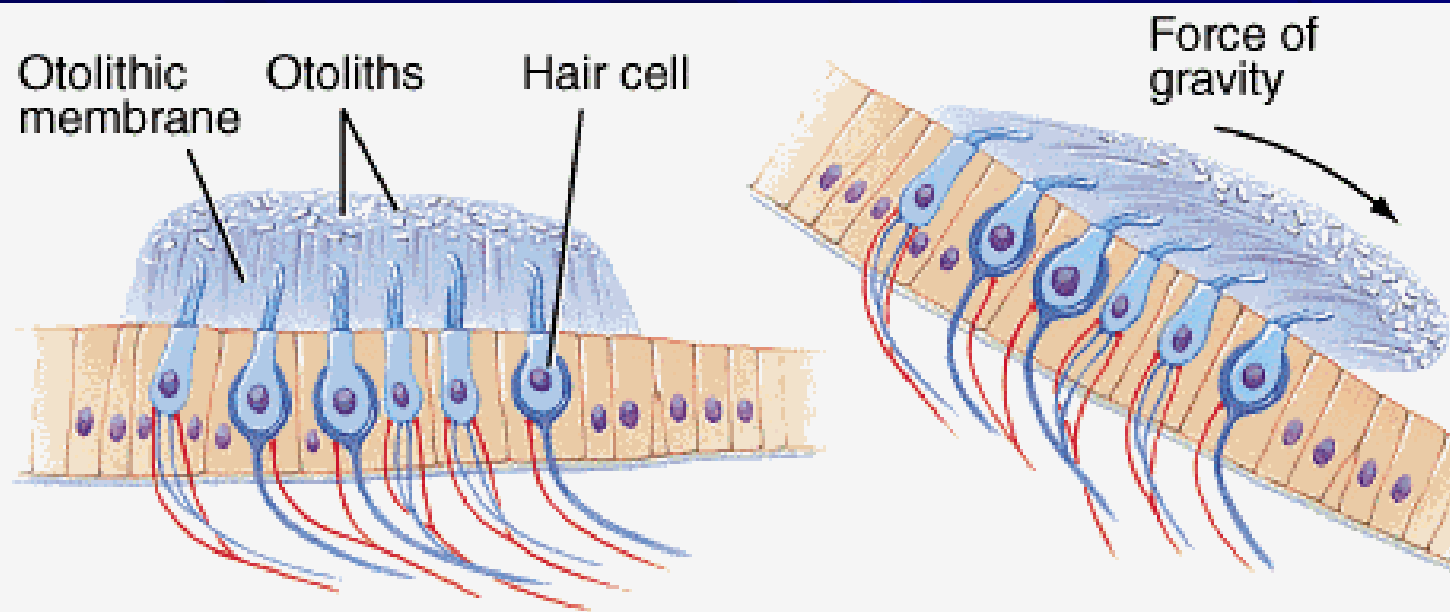






Otolithes CaCO_3





Head upright



Head tilted forward

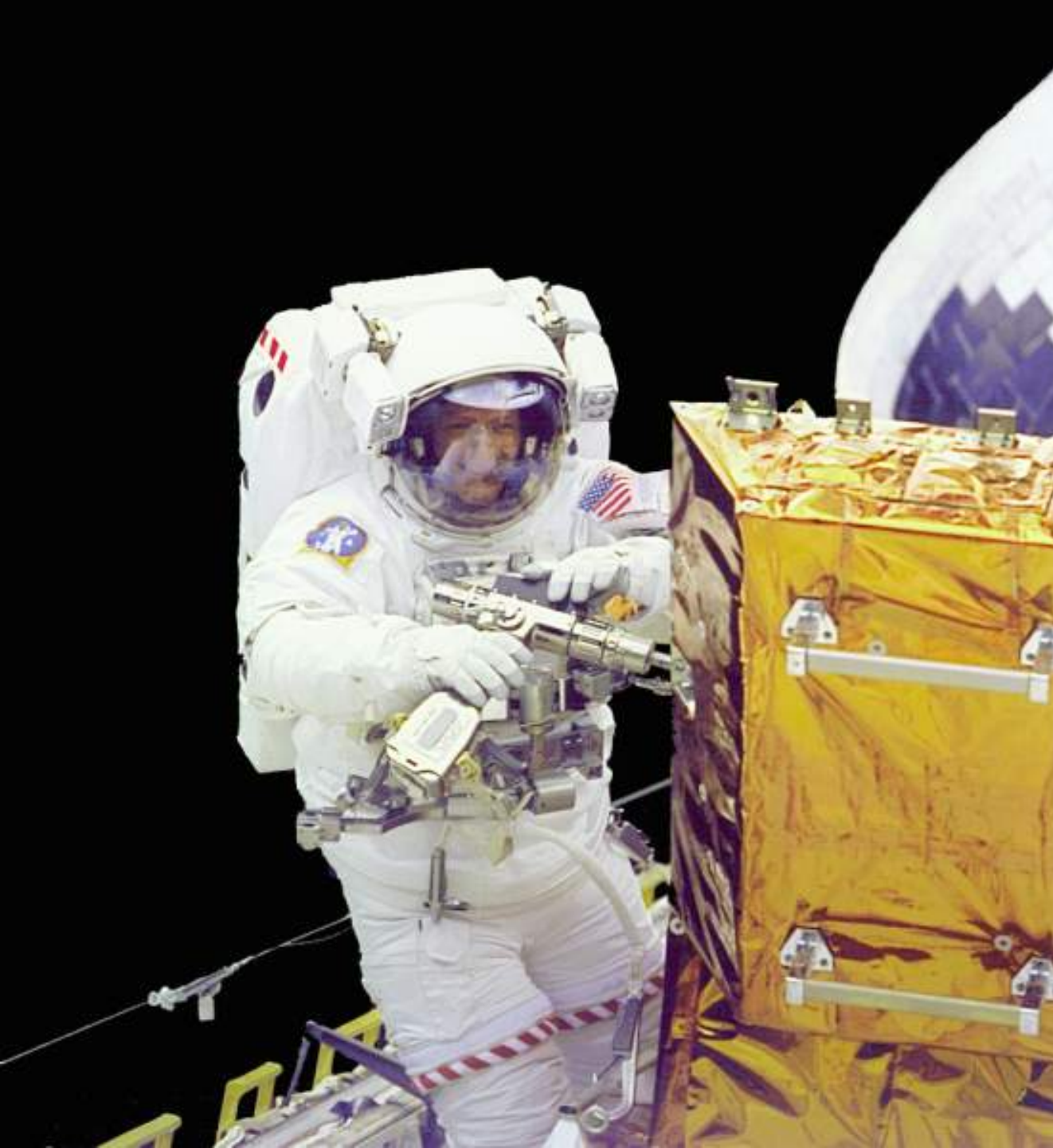


Modifications du système sanguin

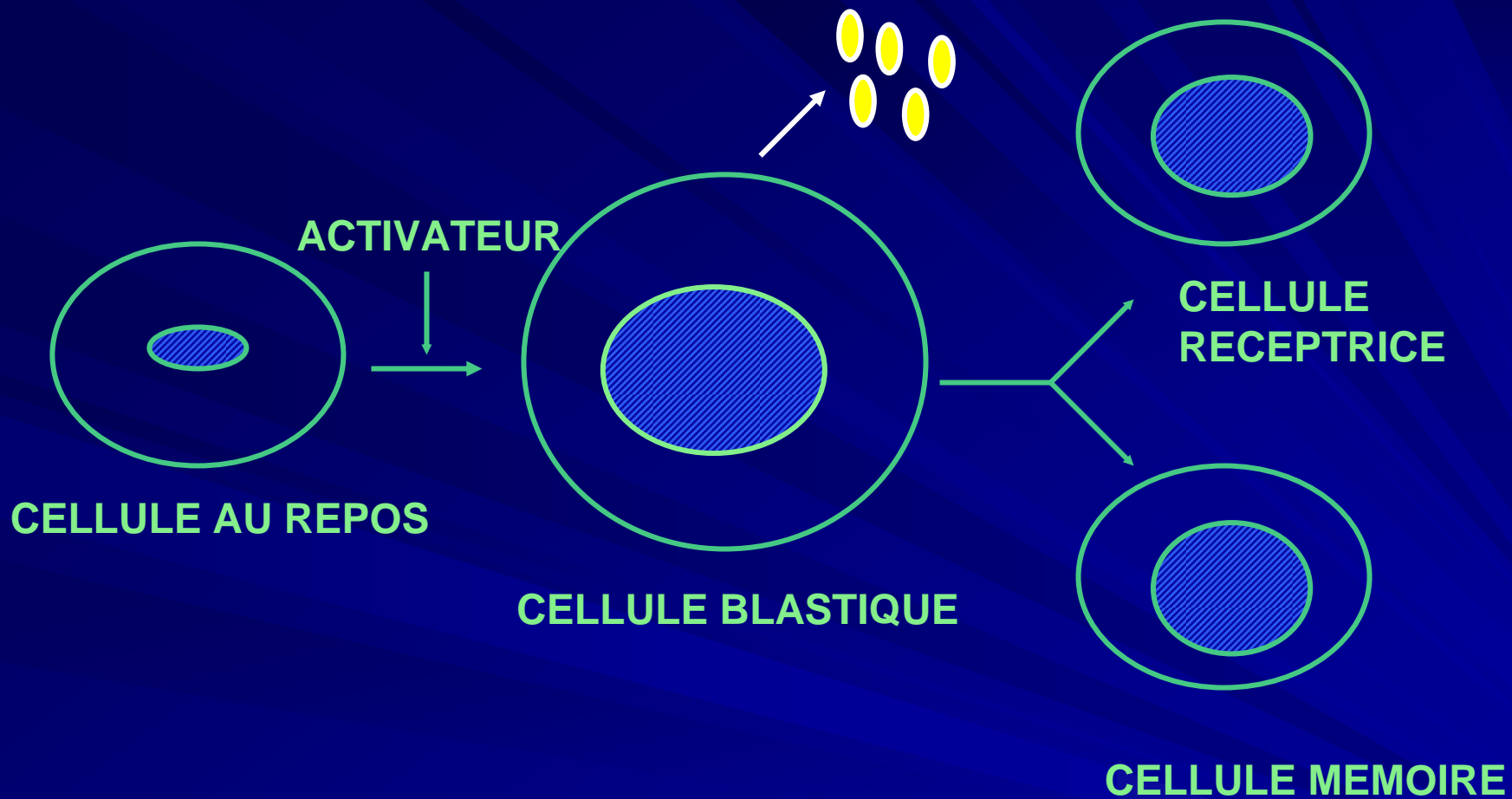
```
graph TD; A([Modifications du système sanguin]) --> B[Réduction des globules rouges]; A --> C[Affaiblissement de la réponse immunitaire];
```

**Réduction
des globules
rouges**

**Affaiblissement
de la
réponse
immunitaire**

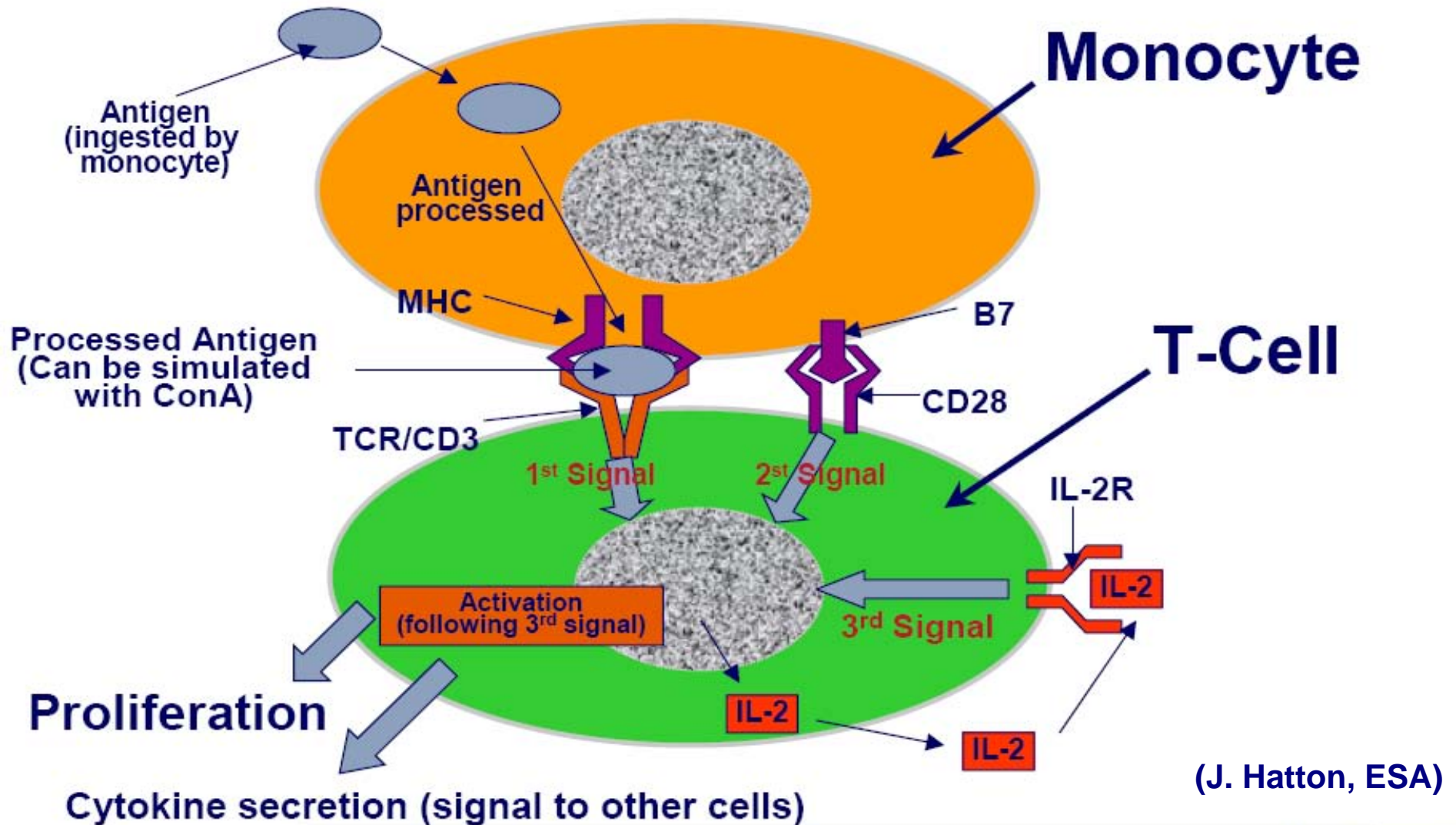


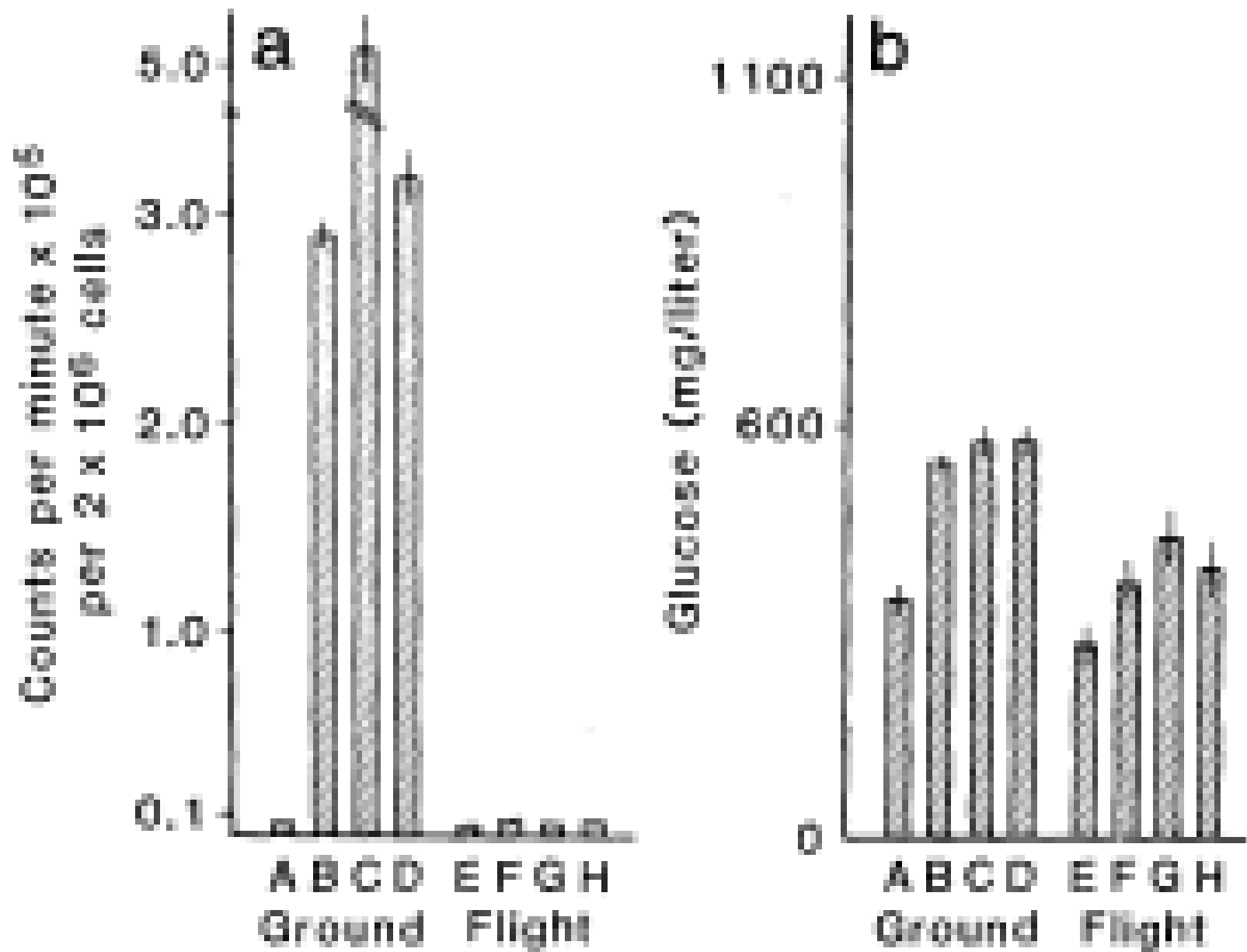
Claude Nicollier
STS-103
19 - 27 décembre
1999
Réparation du
télescope Hubble



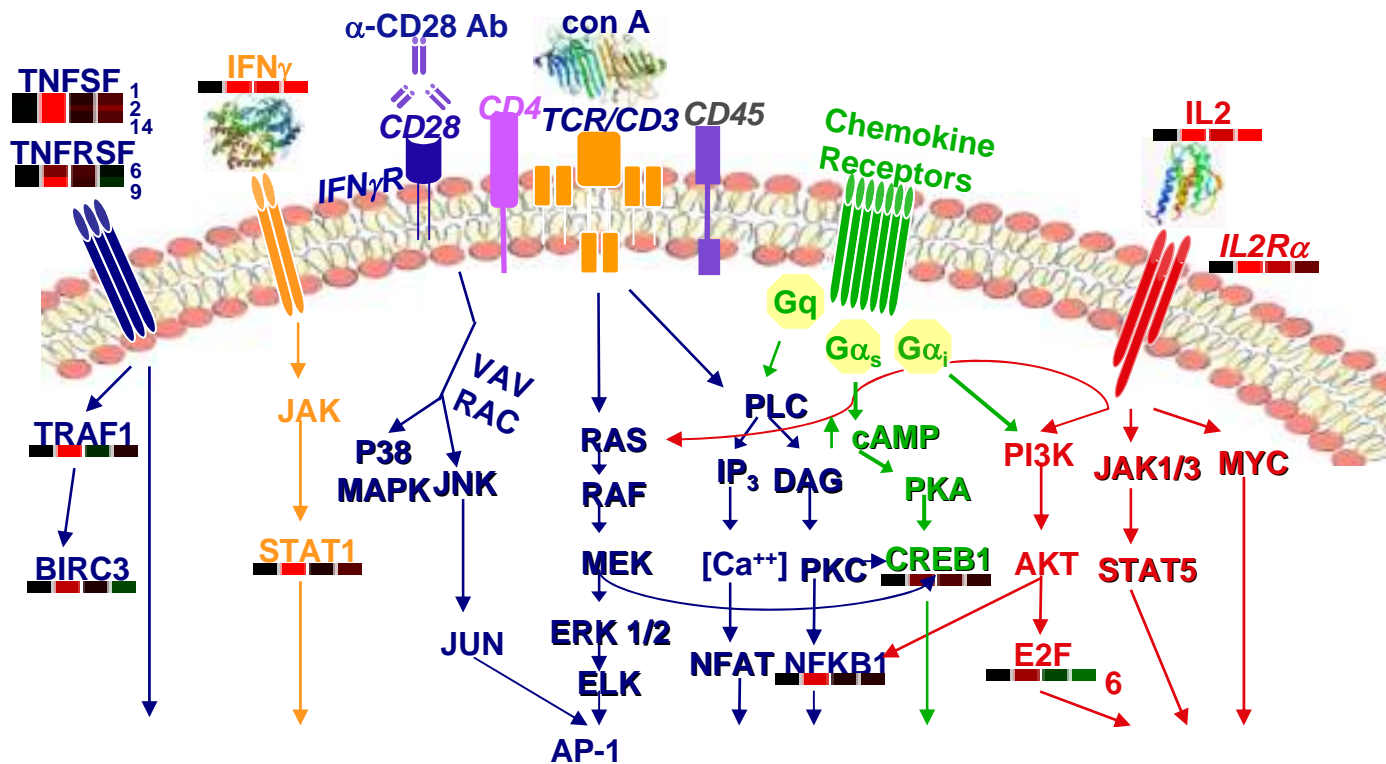
ACTIVATION DE LYMPHOCYTES T

DELIVERY OF SECOND SIGNAL



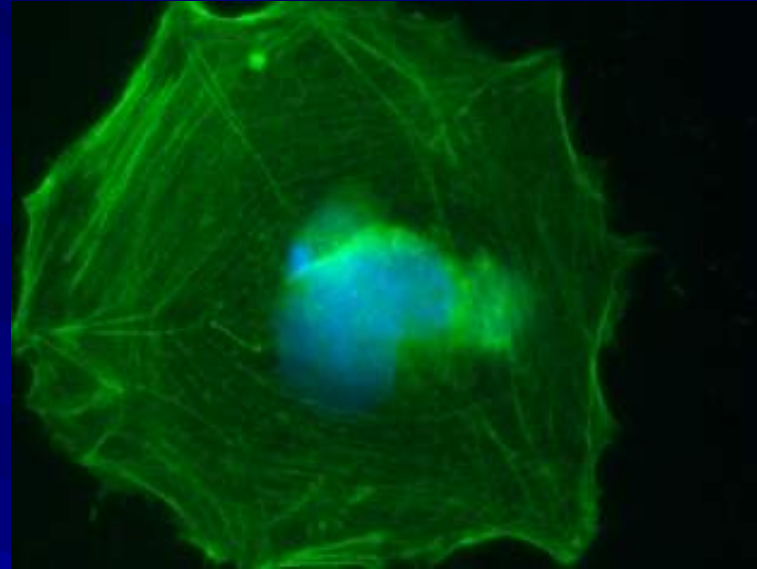
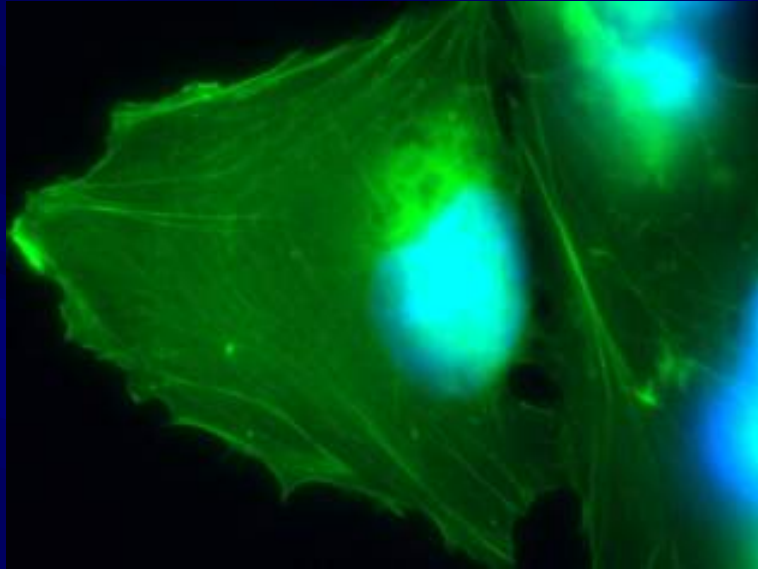


Signaling Pathways Involved in T-cell Activation

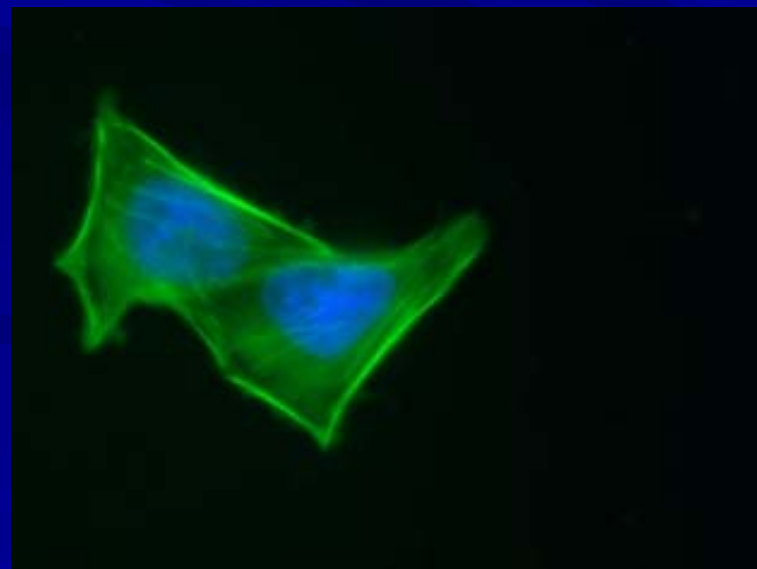
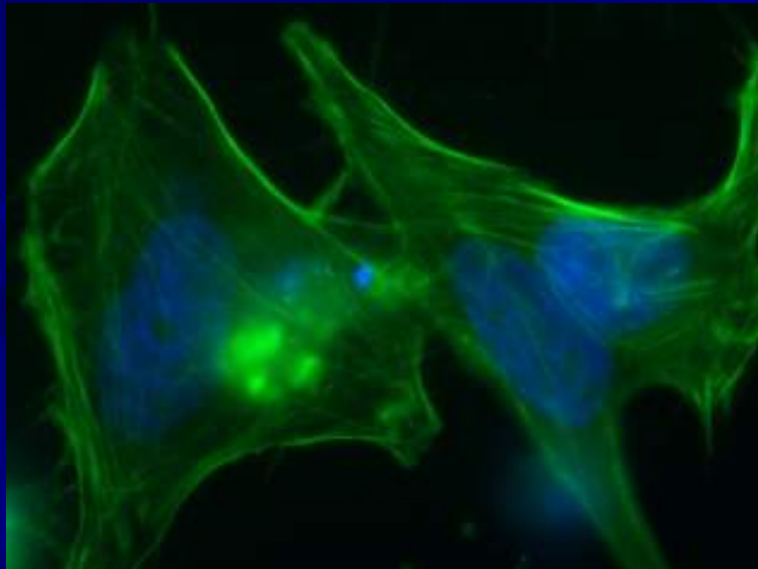


F- ACTIN IN J-111 CELLS IN KUBIK

Pani, Saba, Meloni, Galleri, M. Cogoli



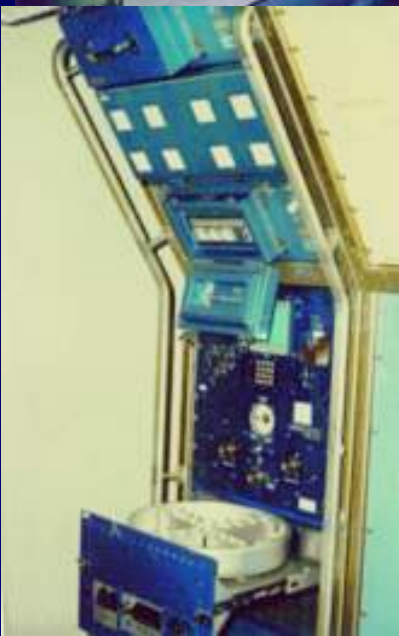
1 G



0 G

Kit de prélèvement sanguin « maison » pour Spacelab

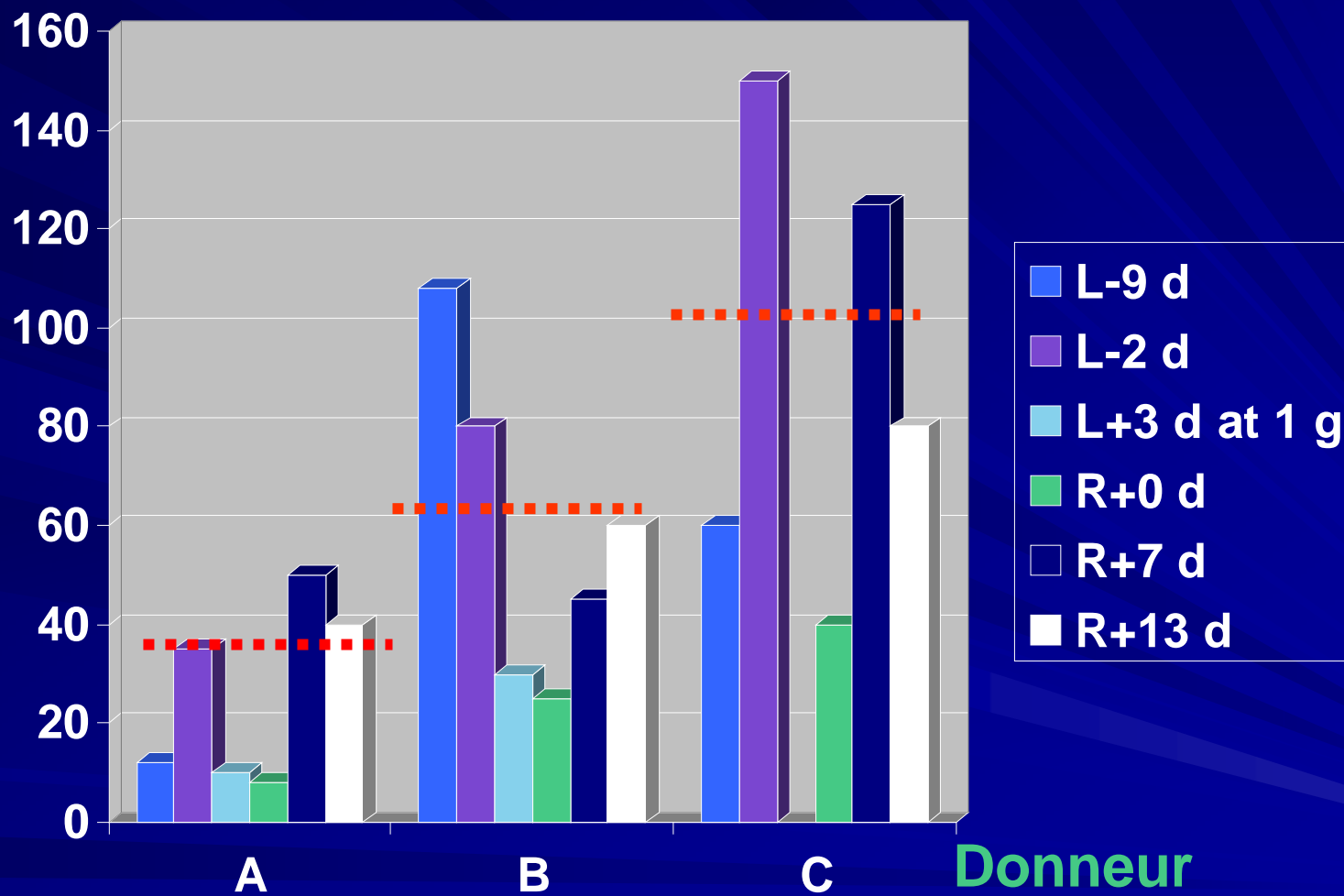




Mission Spacelab Life Science-1, 1991

Prélèvement sanguin après le vol au KSC





Rayonnement cosmique

Rms per Year (log scale)

EARTH'S ATMOSPHERE

1,500

30-70

13-25

7-12

10

2.8

0.08-0.12

0.04-0.06

0.02-0.04

SEA
LEVEL

1,500
METERS

3,000
METERS

12,000
METERS

LOW EARTH
ORBIT

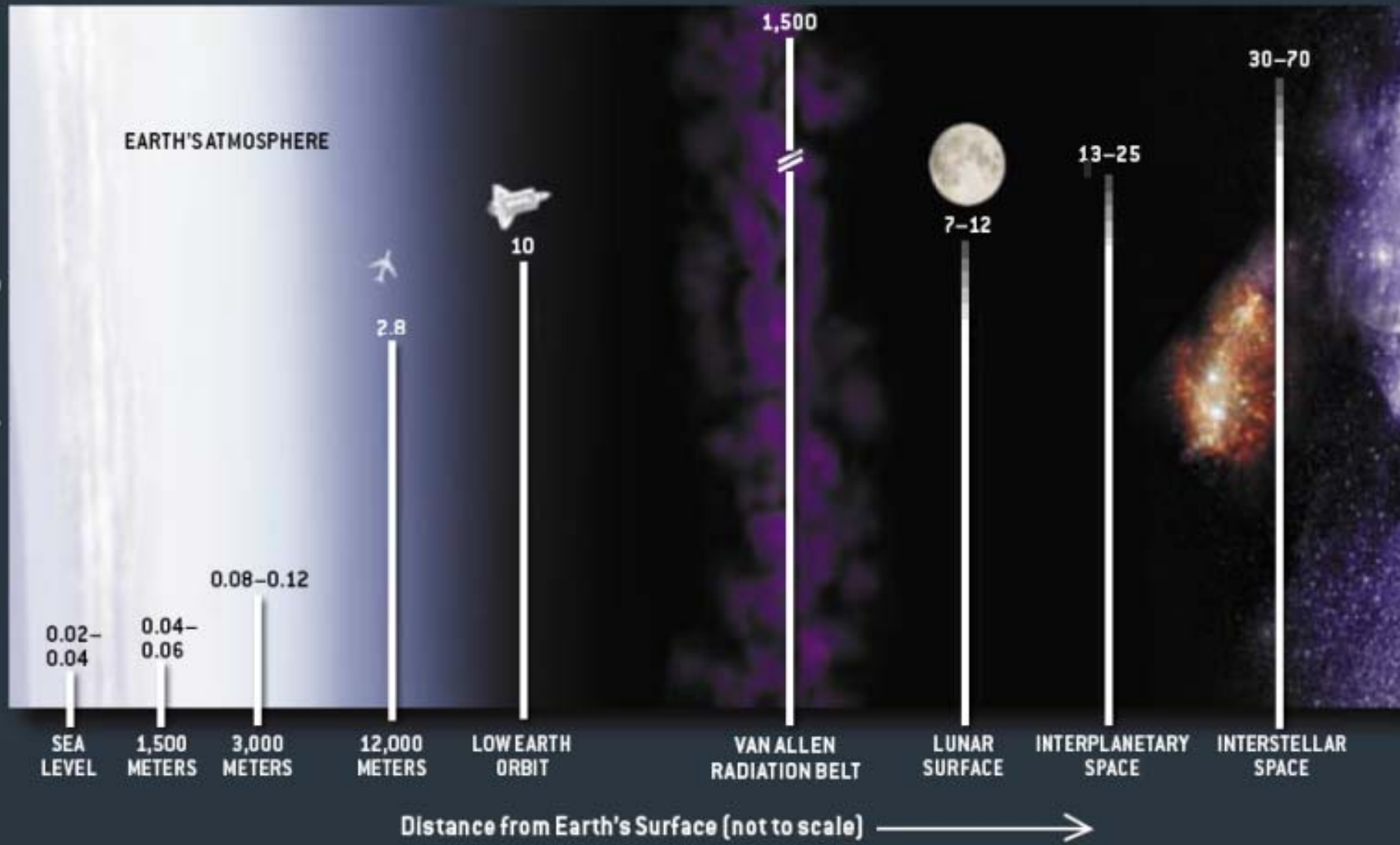
VAN ALLEN
RADIATION BELT

LUNAR
SURFACE

INTERPLANETARY
SPACE

INTERSTELLAR
SPACE

Distance from Earth's Surface (not to scale) →



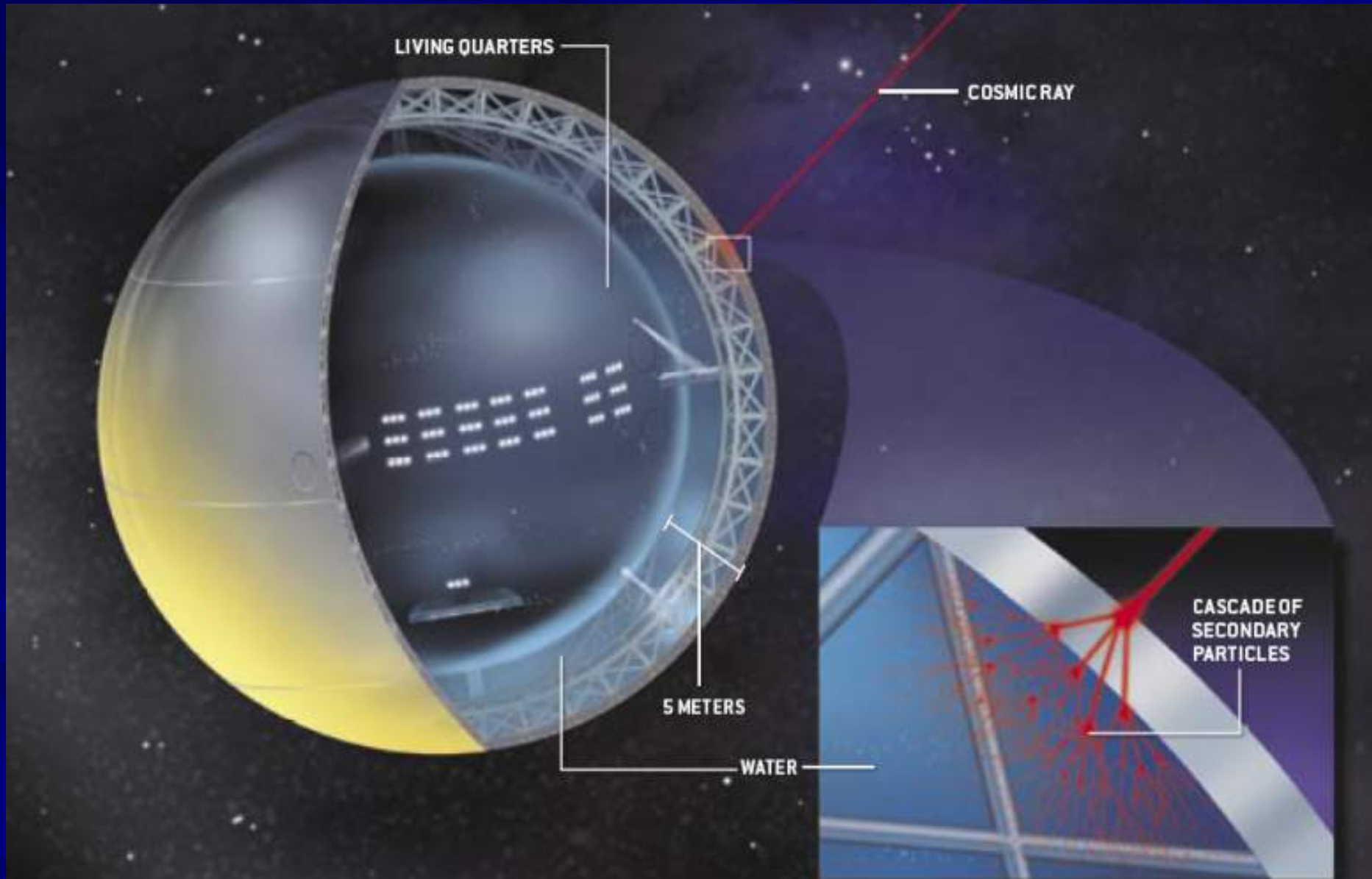
Avantage:

- sûr et fiable

Plan 1: Bouclier d'eau

Inconvénient:

- beaucoup trop lourd



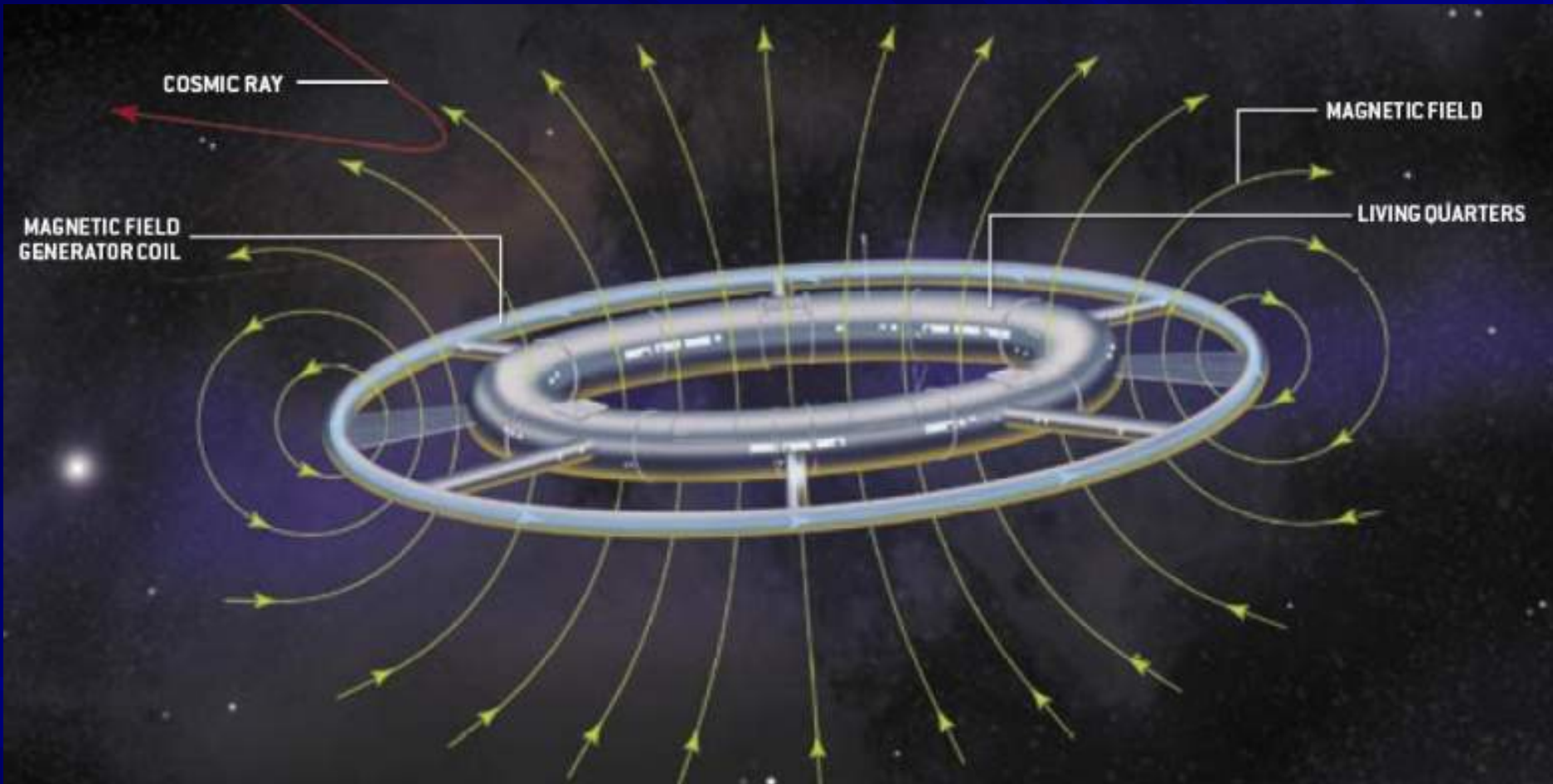
Avantage :

- beaucoup plus léger que le bouclier d'eau

Plan 2: Bouclier magnétique

Inconvénients:

- champ magnétique trop fort
- atteintes à la santé



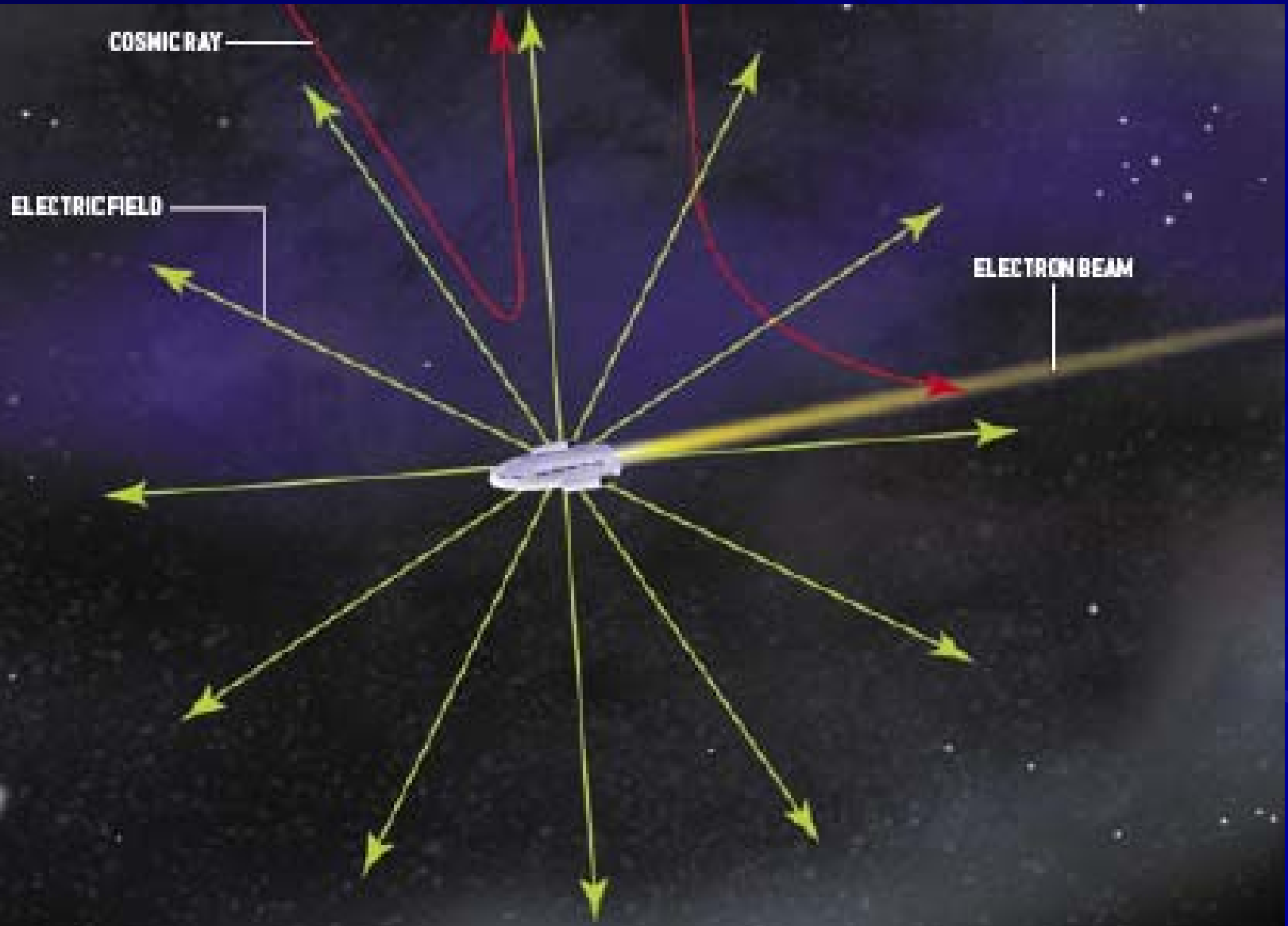
Avantages:

- léger
- pas d'atteinte à la santé

Plan 3: Bouclier électrostatique

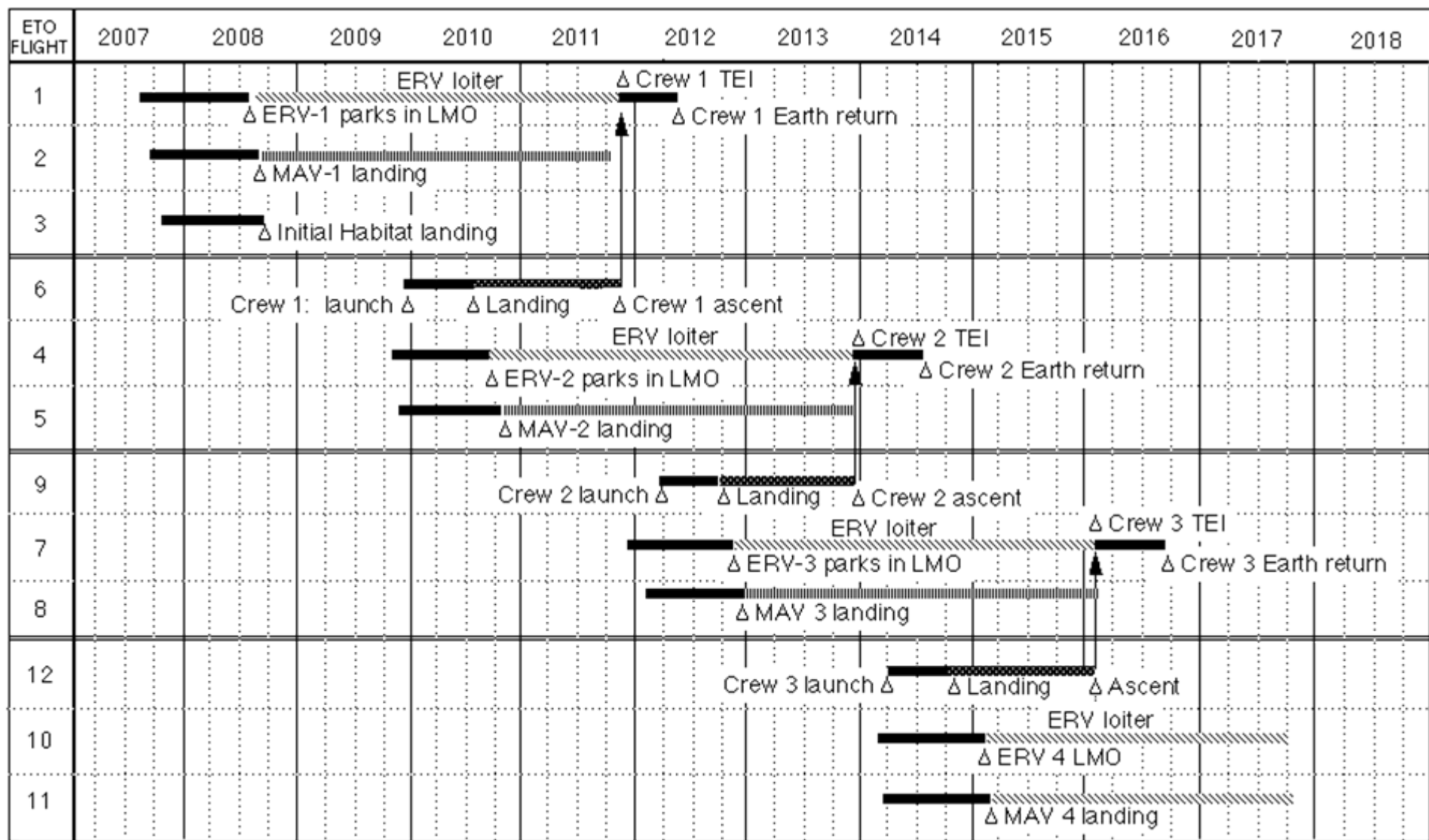
Inconvénient :

- nécessite d'immenses quantités d'électricité



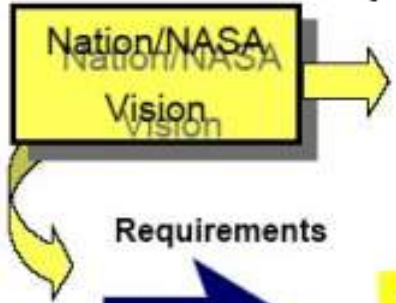
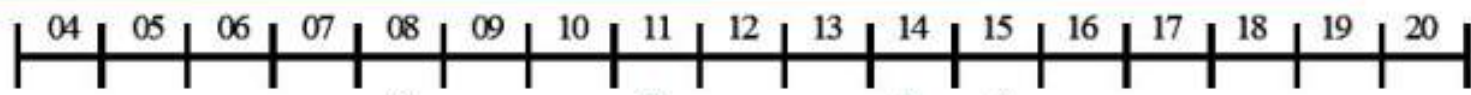
2. La mission Mars

Echéancier de la NASA, années 90

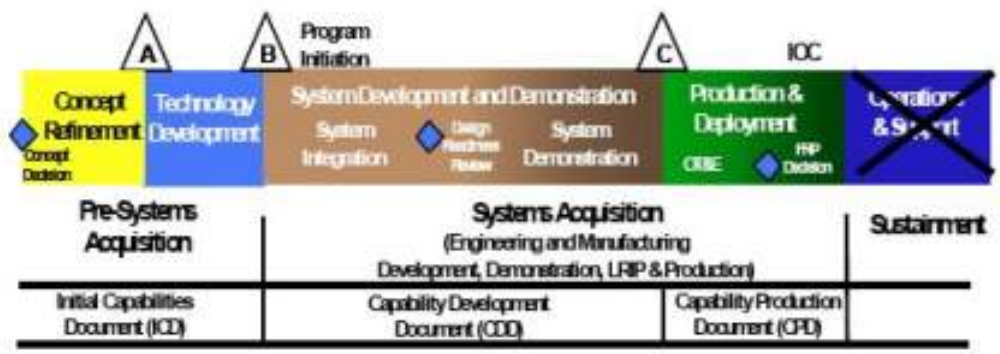




Project Constellation Timeline 4th March 2004



Level 0, 1...
Spiral 1



Unmanned
Space Vehicle

Level 0, 1...
Spiral 2



Manned
Space Vehicle

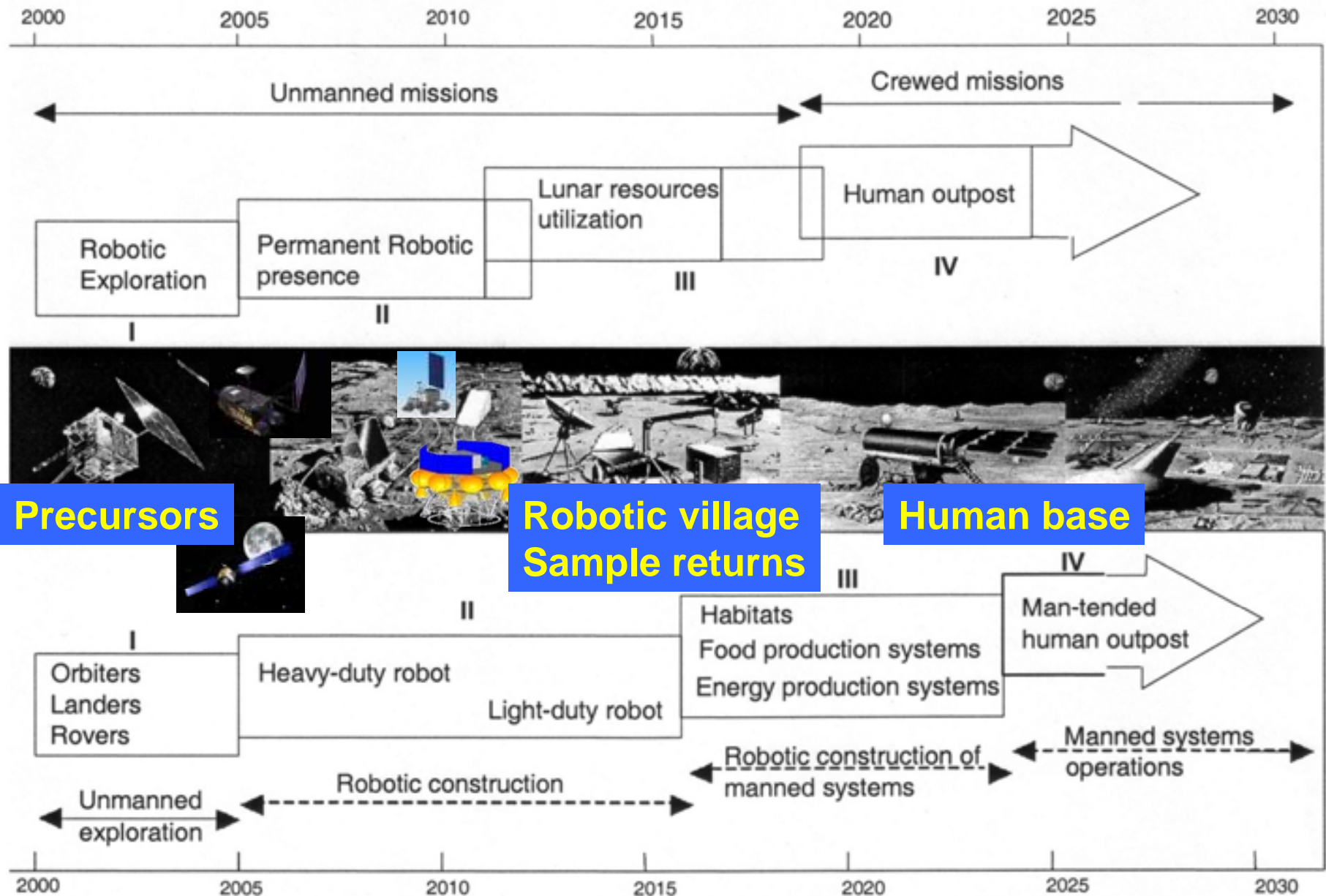
Spiral nth? → Mars (2020+)

Critical Milestones during System Integration and Demonstration (Notional Only)



Non-advocacy Reviews
Independent Cost Reviews

Echéancier de l'exploration lunaire internationale, 2007

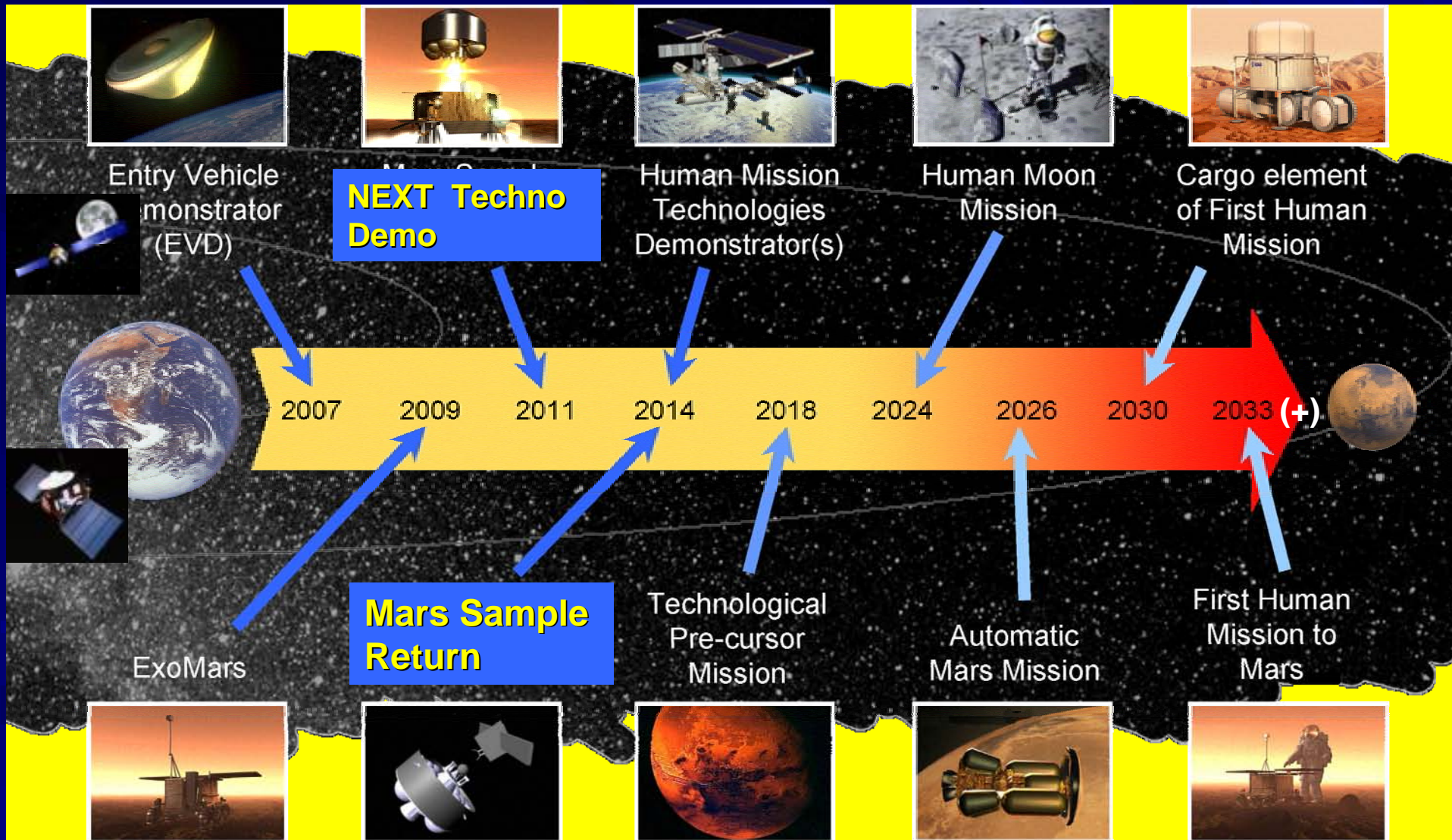


EXPLORATION AU-DELA DE L'ORBITE BASSE TERRESTRE



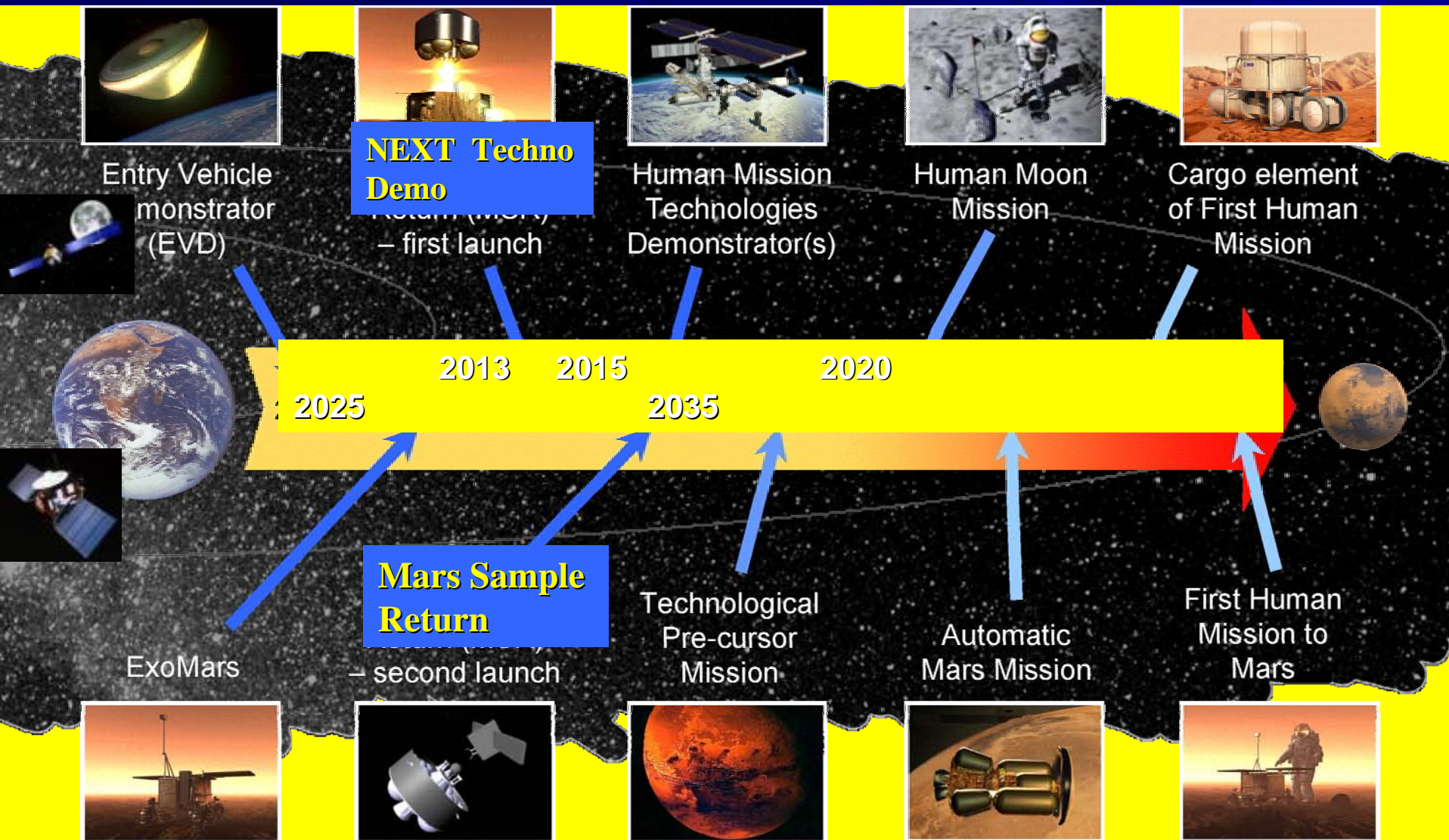
Echéancier de l'exploration Lune-Mars

Programme Aurora, 2001



Echéancier revu de l'exploration Lune-Mars

Programme Aurora, 2007



Processus type de stérilisation d'un échantillon de Mars

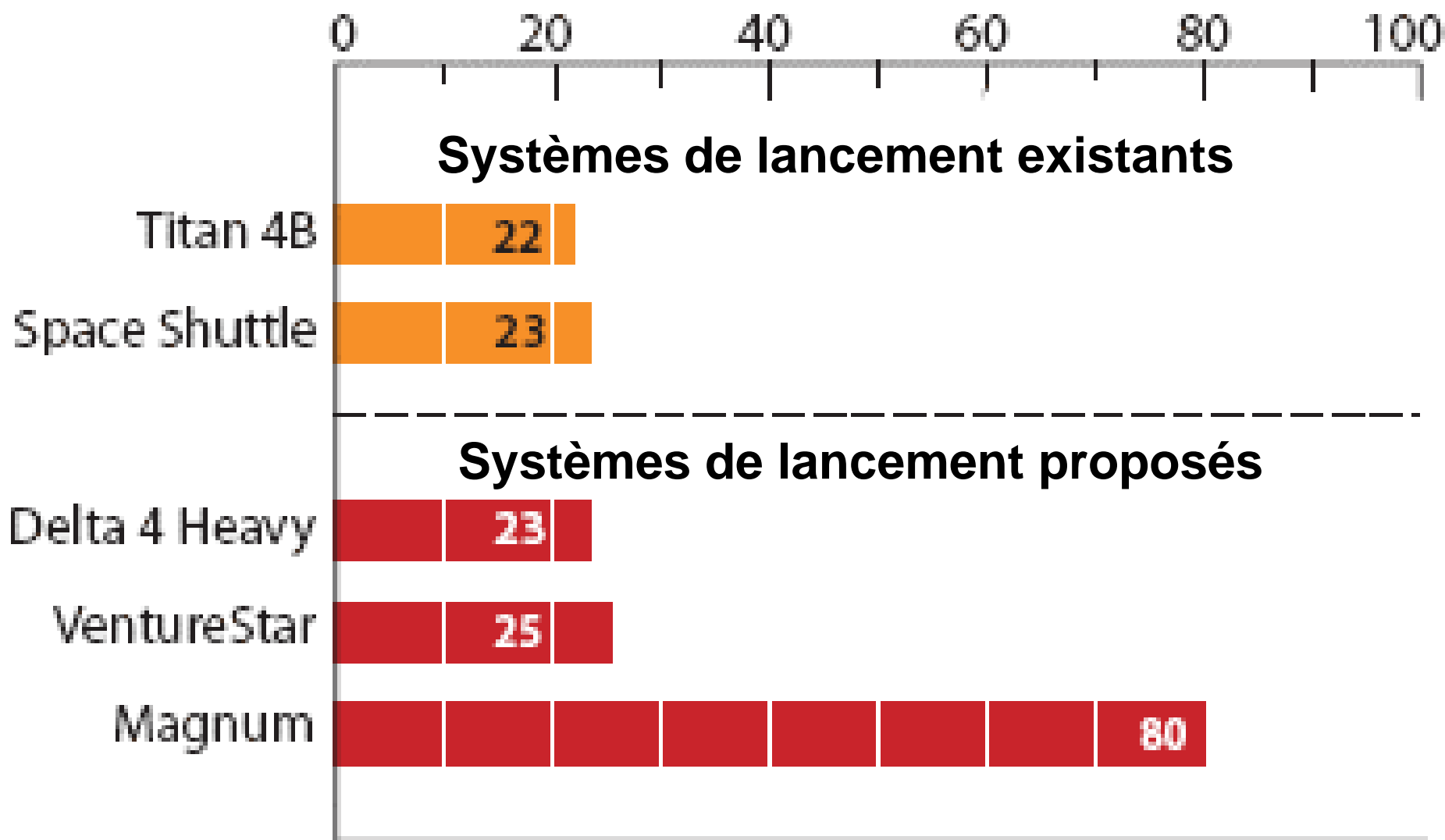


1. « Autonettoyage »
substances chim./alcool

2. Four 120°C
pendant 30 heures

3. Irradiation aux UV

Charge utile (tonnes) à placer en orbite basse



THE NASA REFERENCE MISSION

1 Two unmanned spacecraft launched, assembled in orbit and sent to Mars.

CREW
TRANSFER
VEHICLE

2 Crew transfer vehicle launched 26 months after unmanned craft. Astronauts traverse space for about six months.

HABITAT LANDER

CARGO LANDER

CREW
TRANSFER
VEHICLE

3 On arrival at Mars, astronauts move to the habitat lander, which has been orbiting the planet. They descend to the surface, touching down next to the cargo lander.

EARTH RETURN
CAPSULE

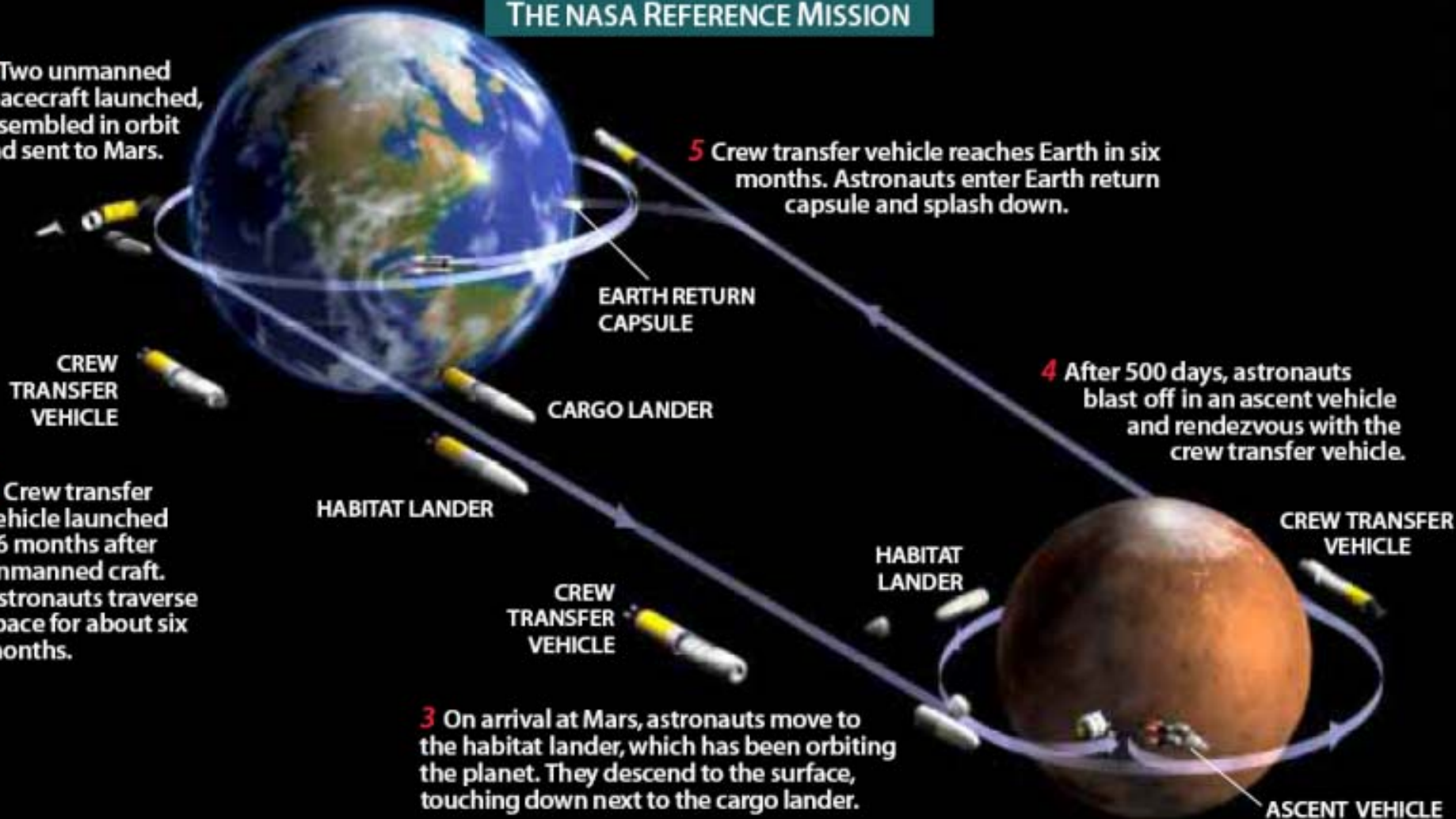
5 Crew transfer vehicle reaches Earth in six months. Astronauts enter Earth return capsule and splash down.

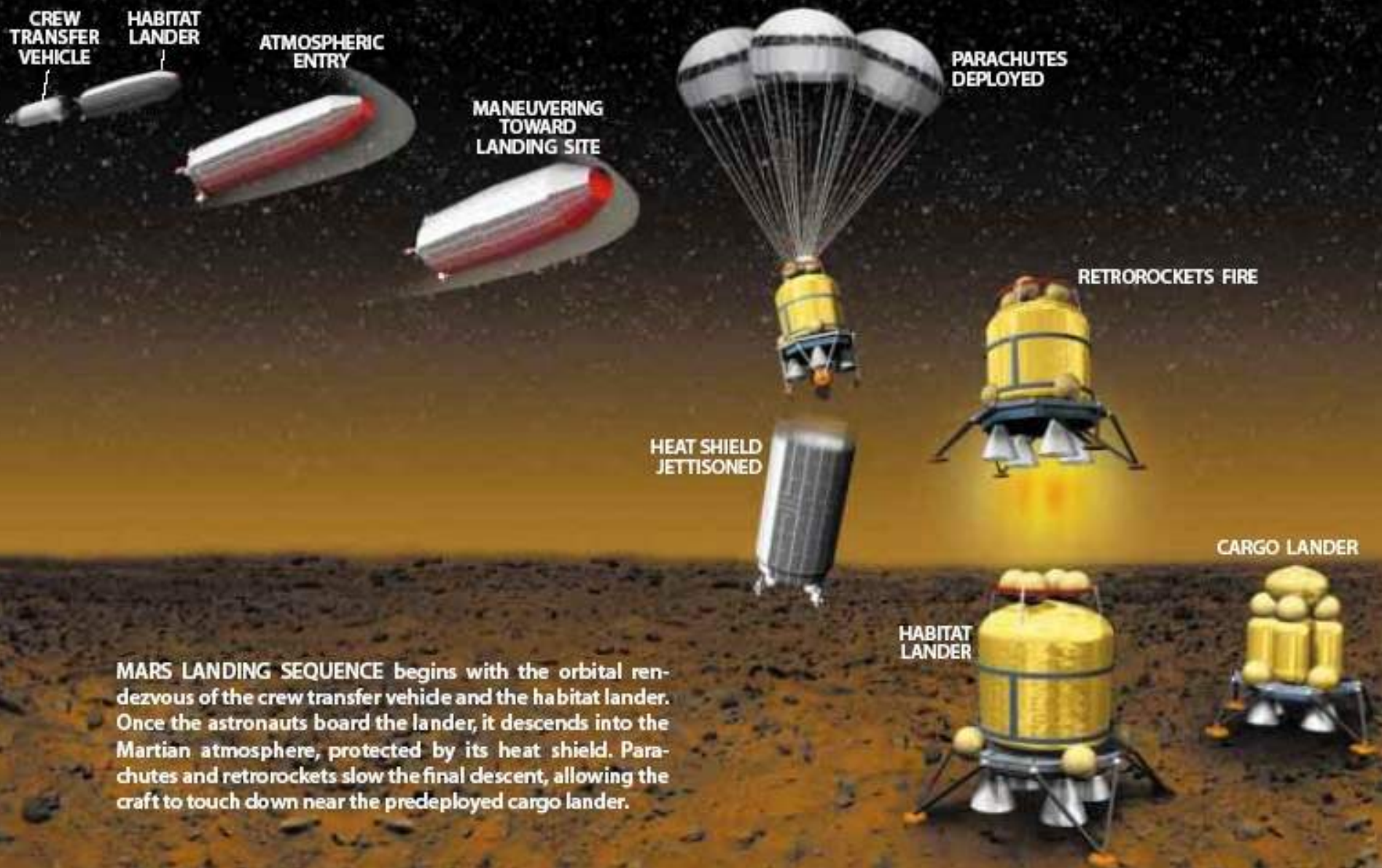
4 After 500 days, astronauts blast off in an ascent vehicle and rendezvous with the crew transfer vehicle.

CREW TRANSFER
VEHICLE

HABITAT
LANDER

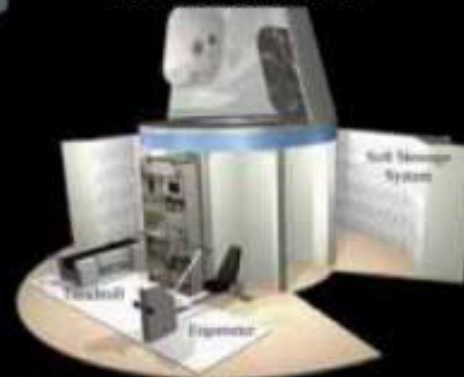
ASCENT VEHICLE



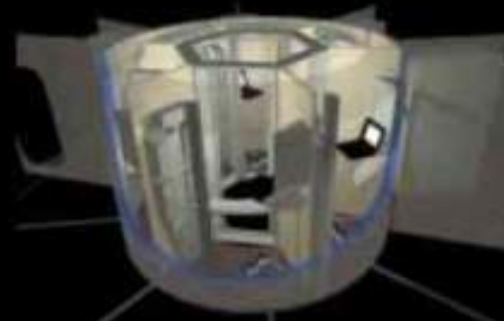


TransHab

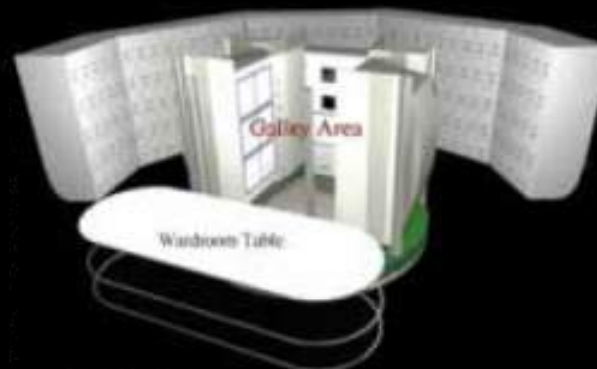
LEVEL 4 -
Pressurized tunnel area



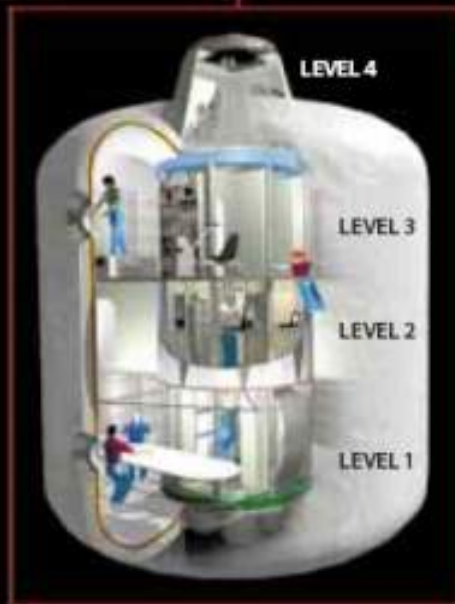
LEVEL 3 - Crew health care area



LEVEL 2 - Mechanical room and crew quarters

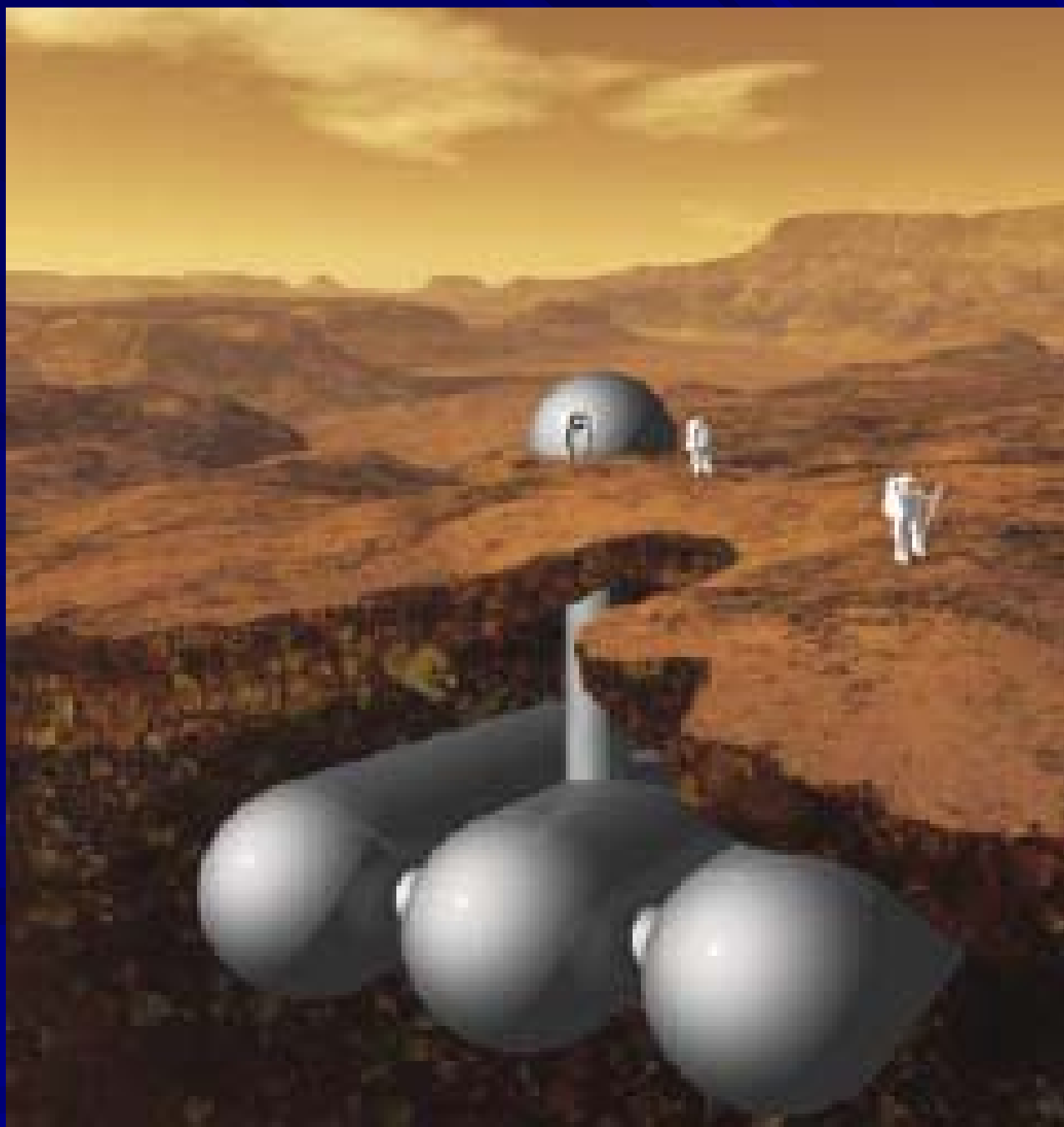


LEVEL 1 - Wardroom and galley area









Coucher de soleil sur Mars

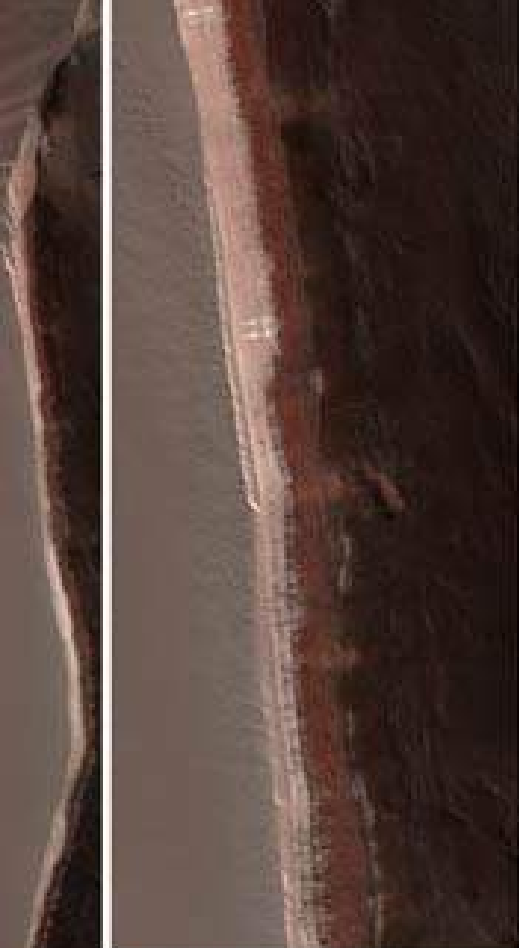
Viking, 1975



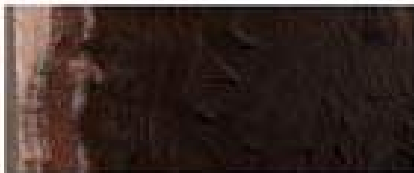
Spirit, 2005



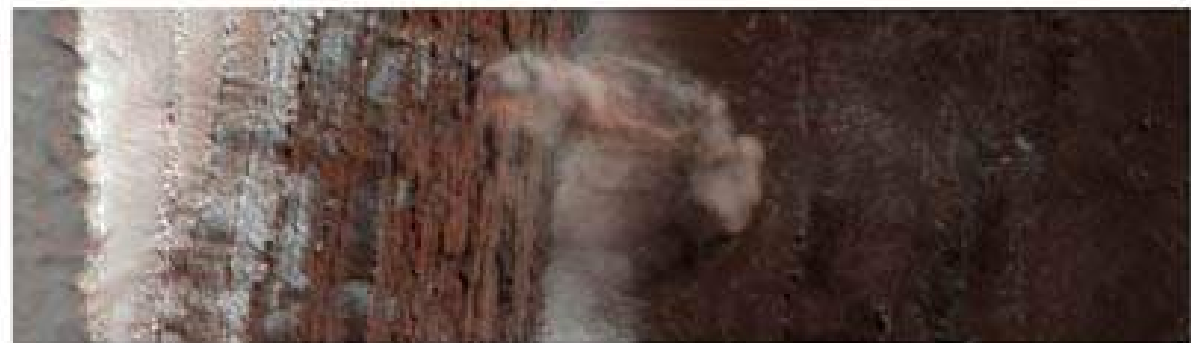
PSP_007338_2640



"Ingrid's
Avalanches" 2008 Feb 19



83.7N 235.8E



Avalanche de neige et de rochers sur Mars



Mars Science Laboratory, NASA

Départ: automne 2009, arrivée: octobre 2010

3. Soins hygiéniques et médicaux







Ozonisateur



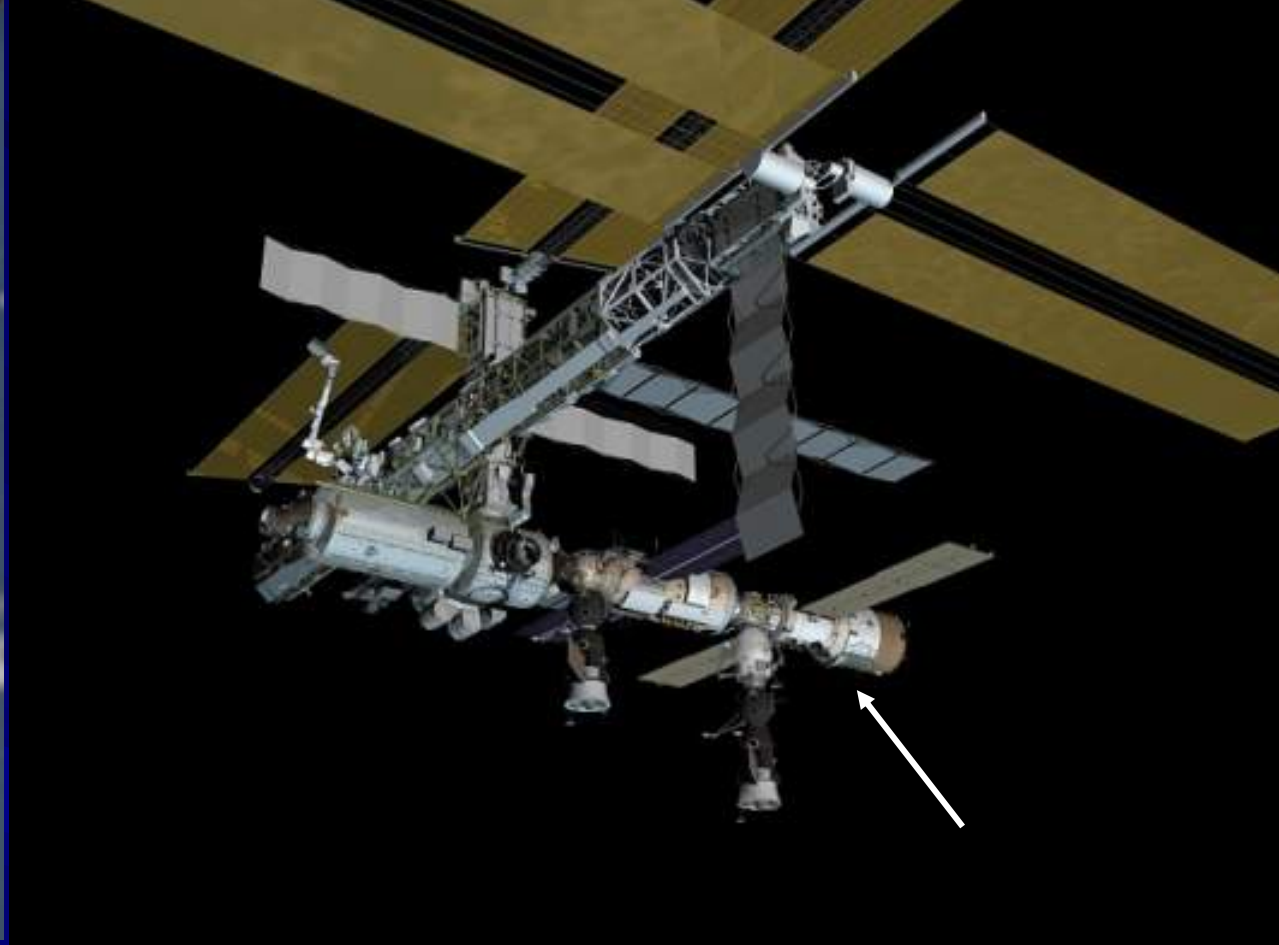
Boîte à gants stérile

Surgery and Recovery in Space

Authors

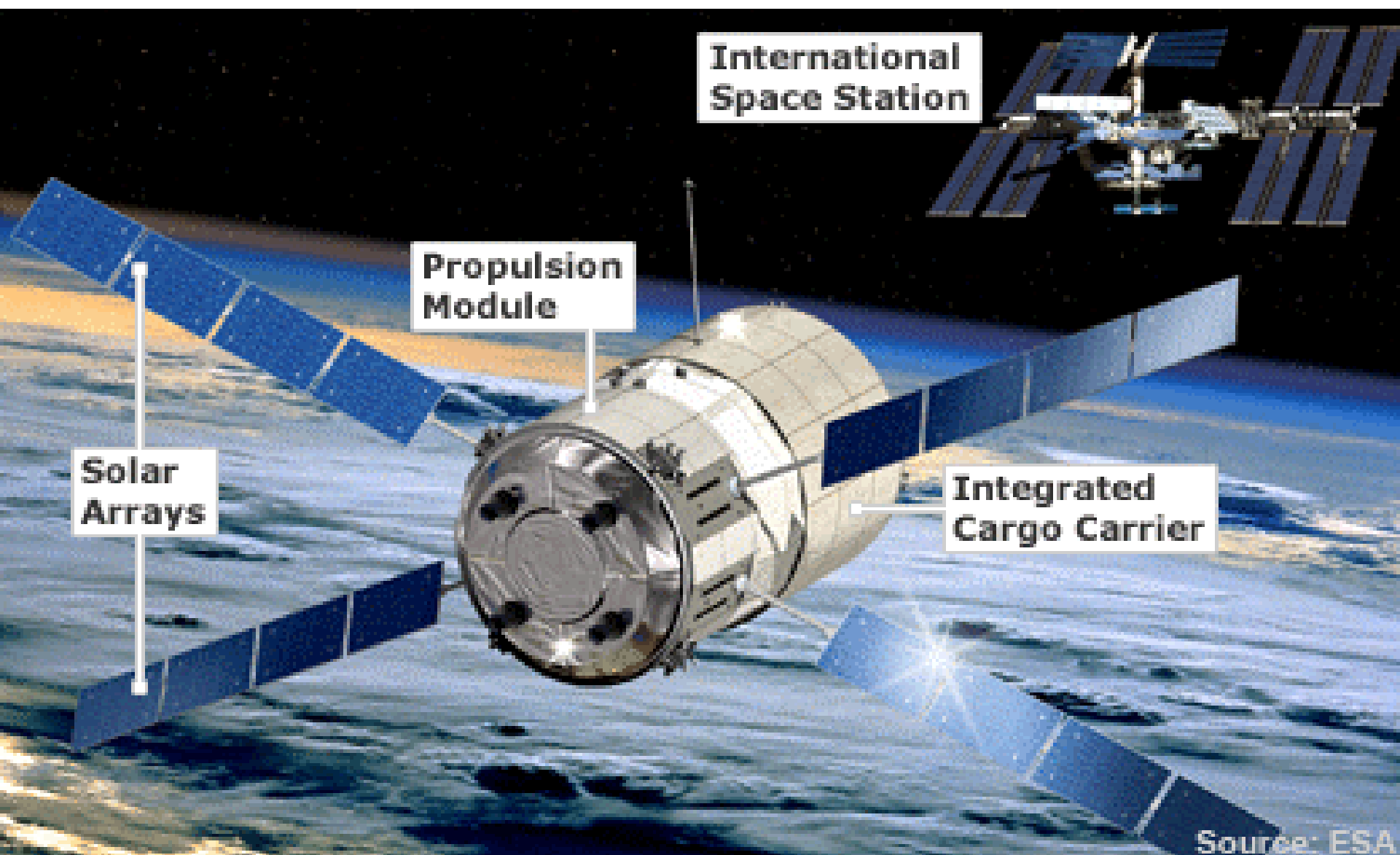
Jay C. Buckey, Jr., Dafydd R. Williams, Danny A. Riley

4. Recyclage des déchets



***Progress, le vaisseau cargo russe
(ravitaillement et élimination des déchets)***

AUTOMATED TRANSFER VEHICLE (ATV)

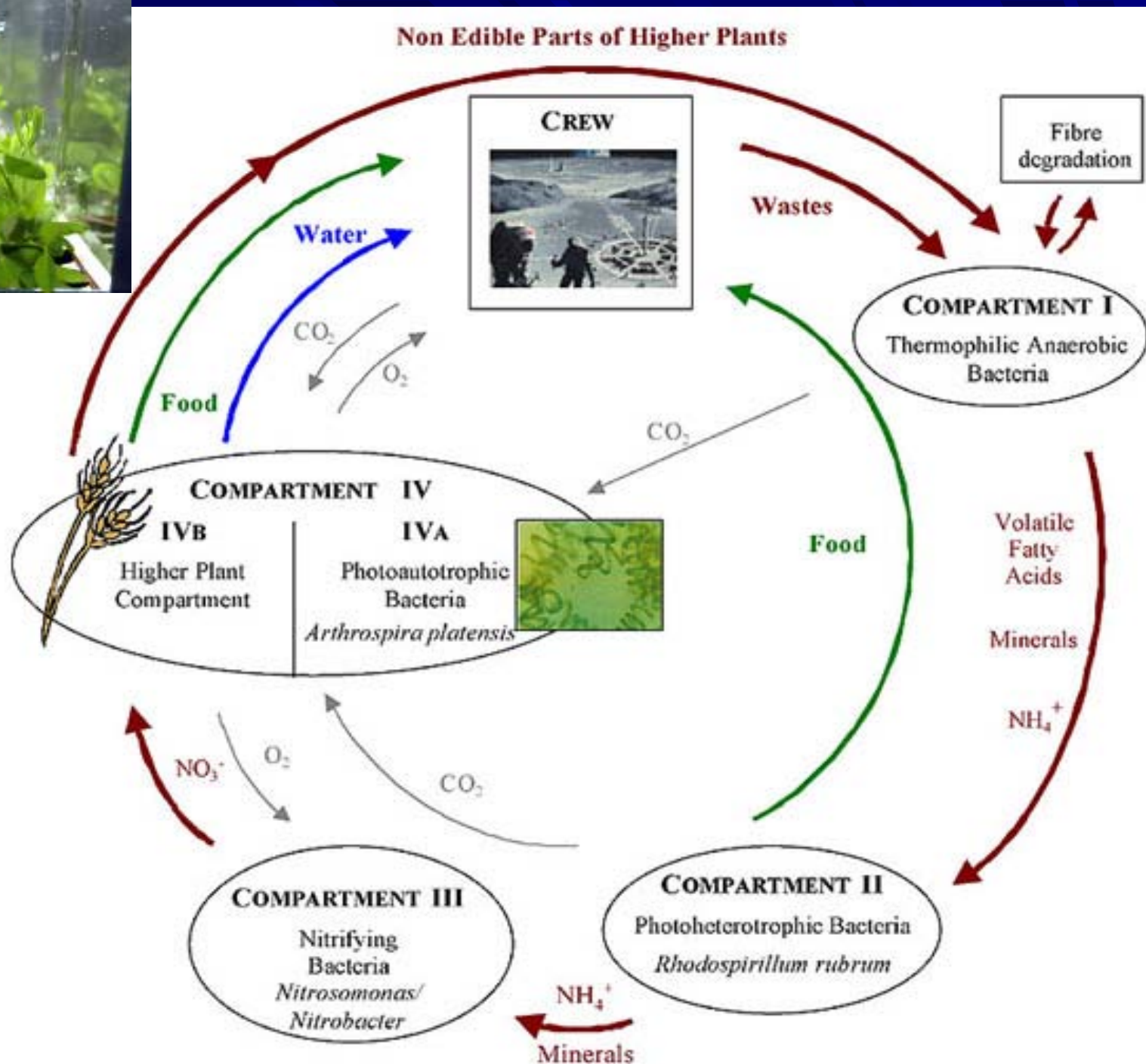


ATV (véhicule automatique de transfert), le vaisseau cargo européen

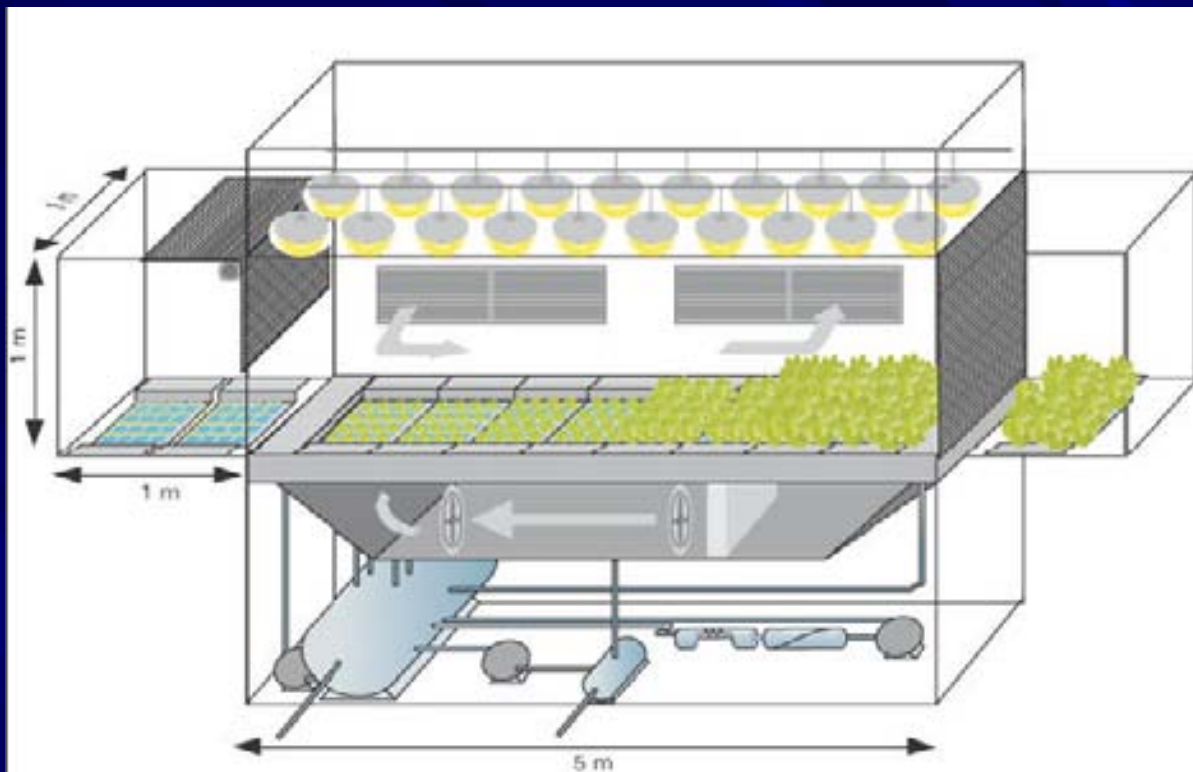


Concept MELISSA

Micro- Ecological Life Support System Alternative







5. Perspectives

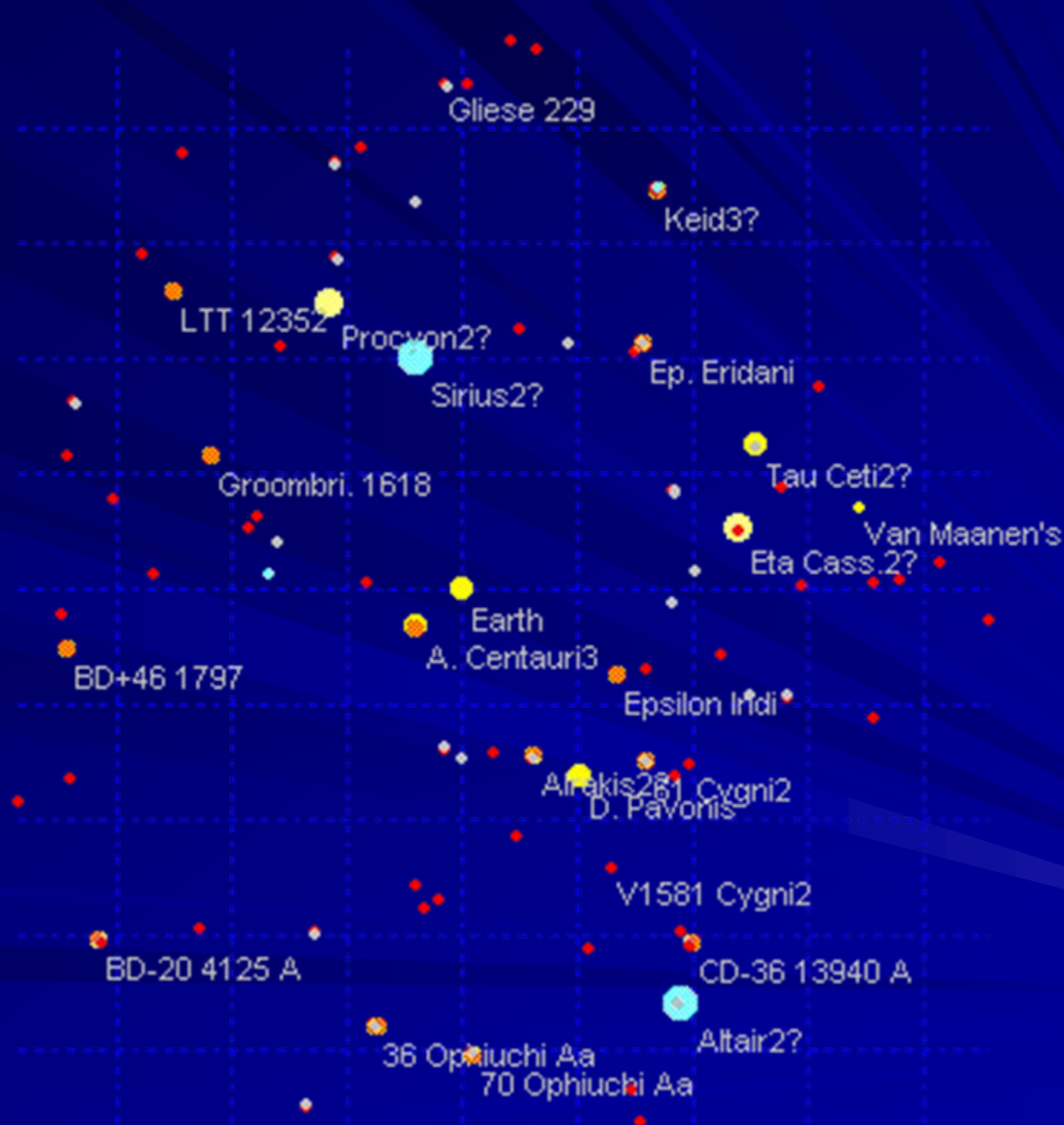
nature

INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

Volume 352 No. 6335 8 August 1991 £2.50



BRINGING MARS TO LIFE

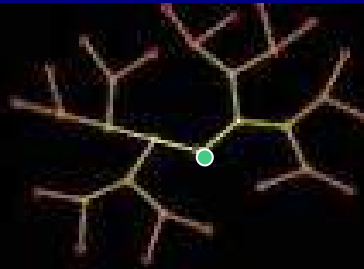


Après 1500 ans

Planète-mère



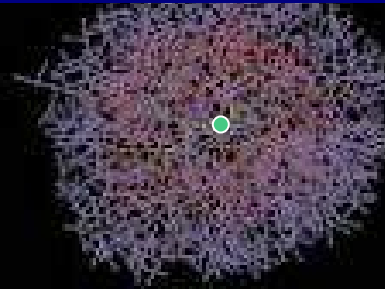
Après 2000 ans



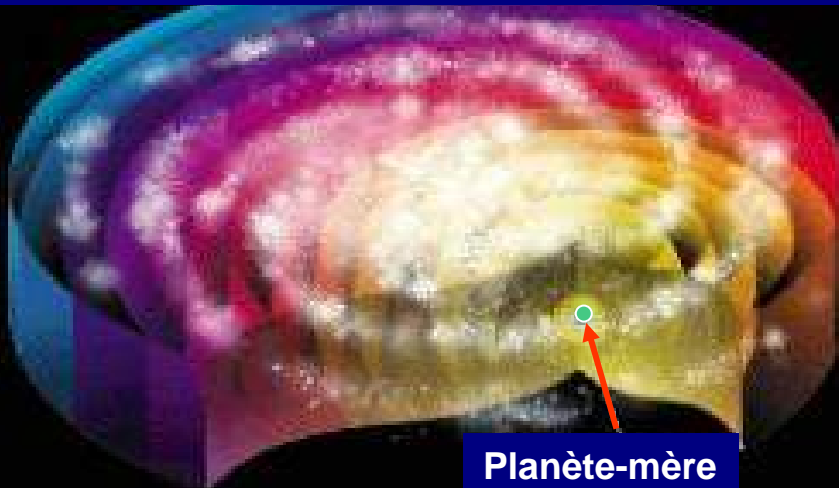
Après 3500 ans



Après 5000 ans



Après 3,75 millions d'années, notre galaxie sera complètement colonisée



Planète-mère

Tiré de:

J. Crawford

Sci. Am., juillet 2000

Merci de votre attention!