Voyage vers Mars:
Aspects médicaux et biologiques

Augusto Cogoli

Zero-g LifeTec GmbH

4es 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.

Zero-g LifeTec GmbH

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

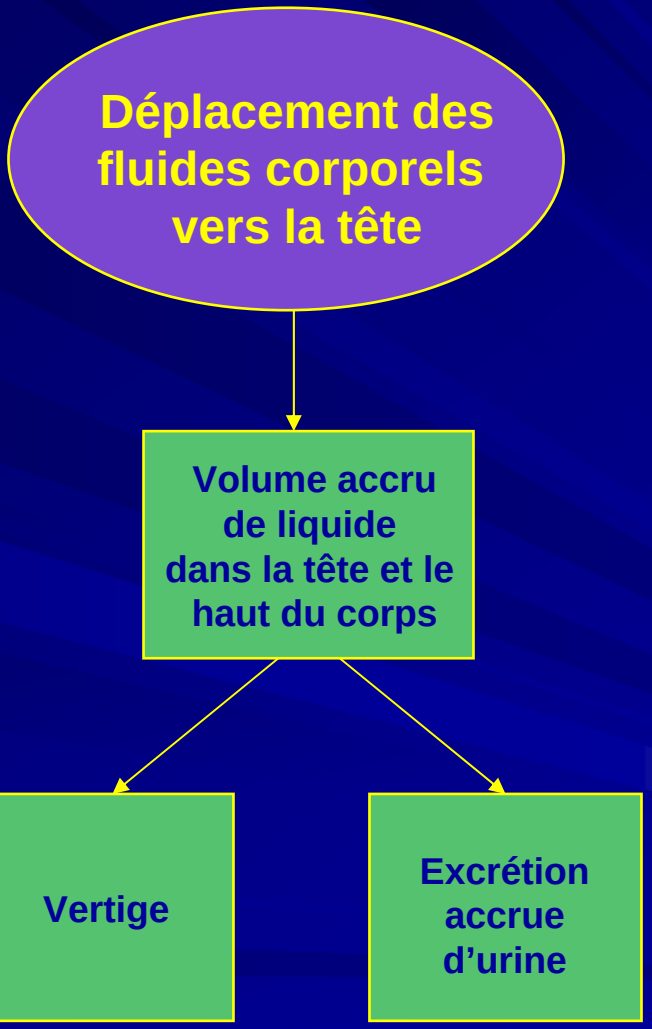
Astronaute Bruce McCandless

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

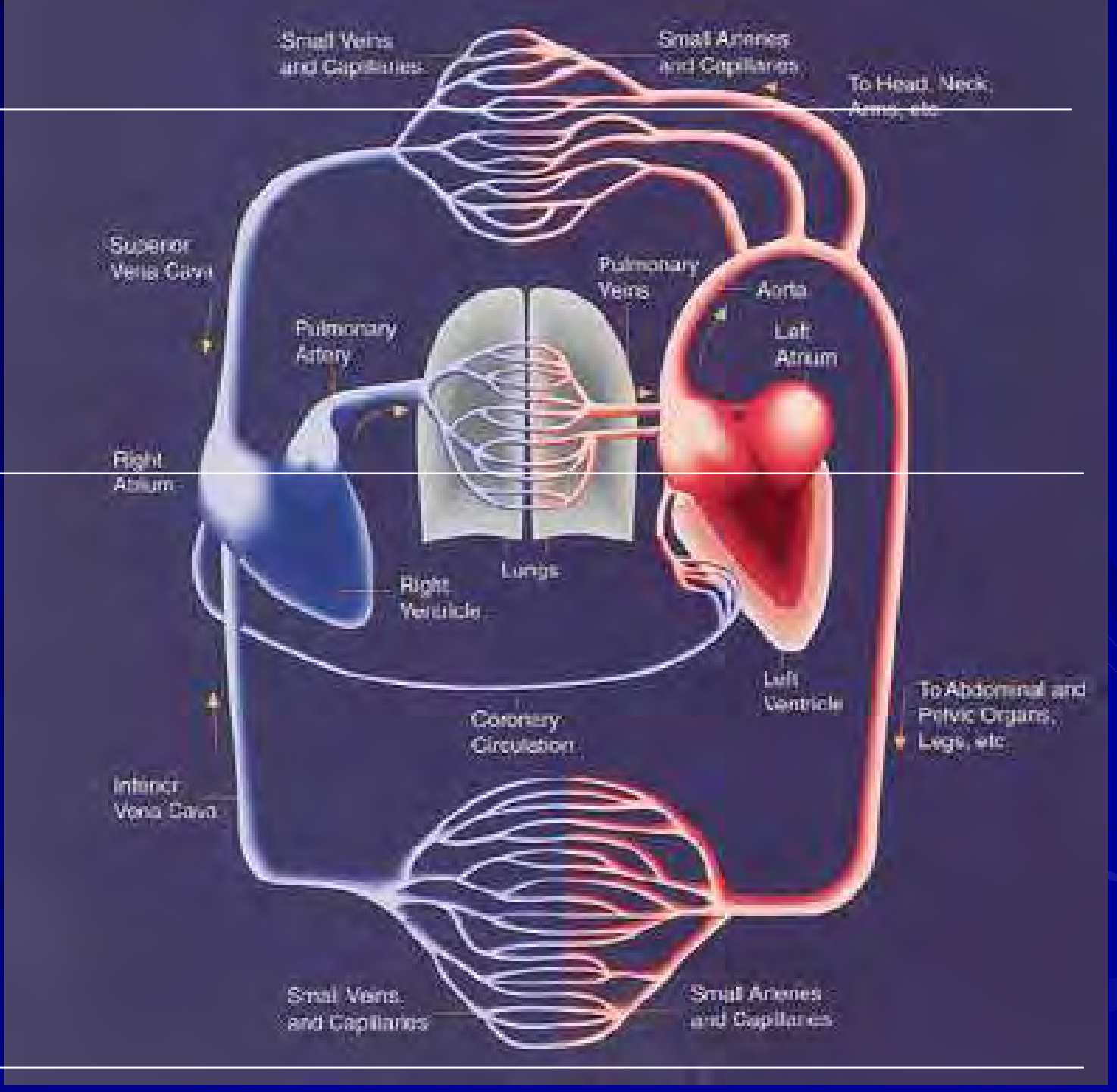

Déplacement des fluides corporels vers la tête
Volume accru de liquide dans la tête et le haut du corps
Vertige
Excrétion accrue d'urine

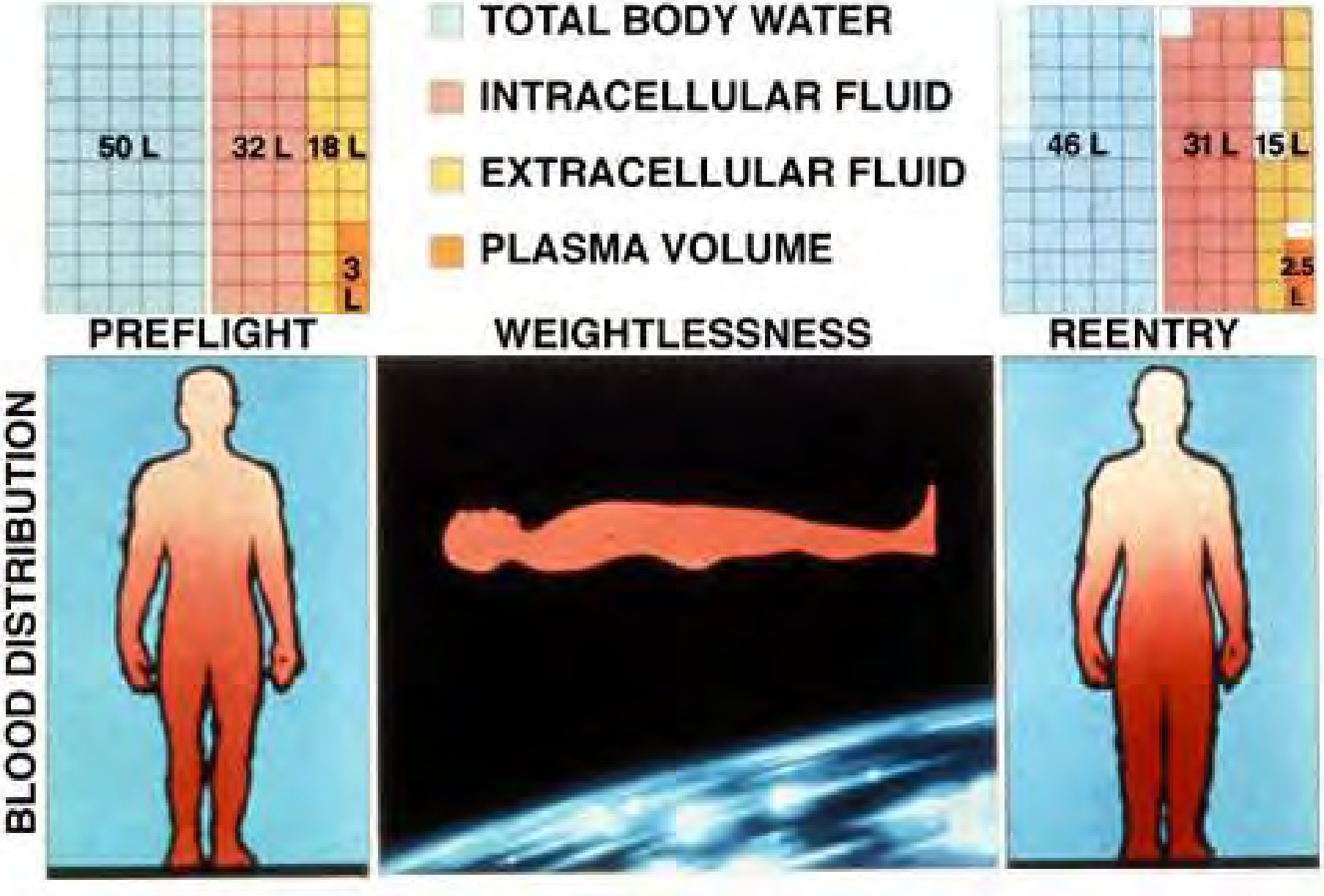
Jim Bagian

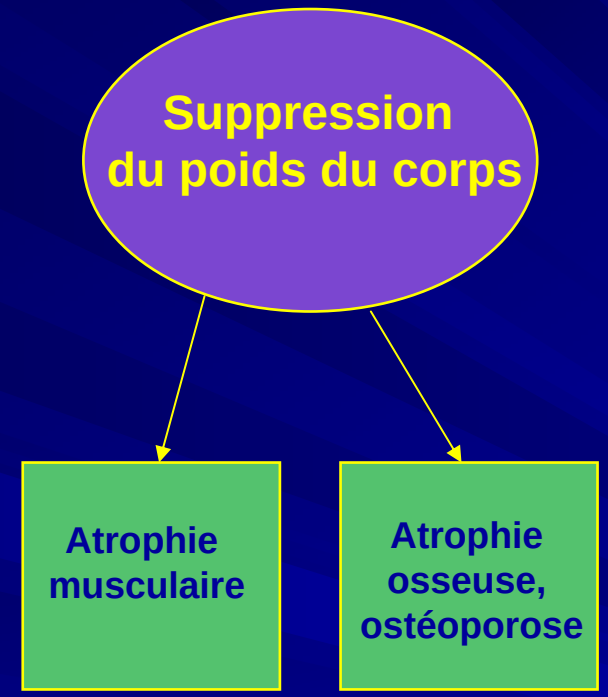
60 mm Hg

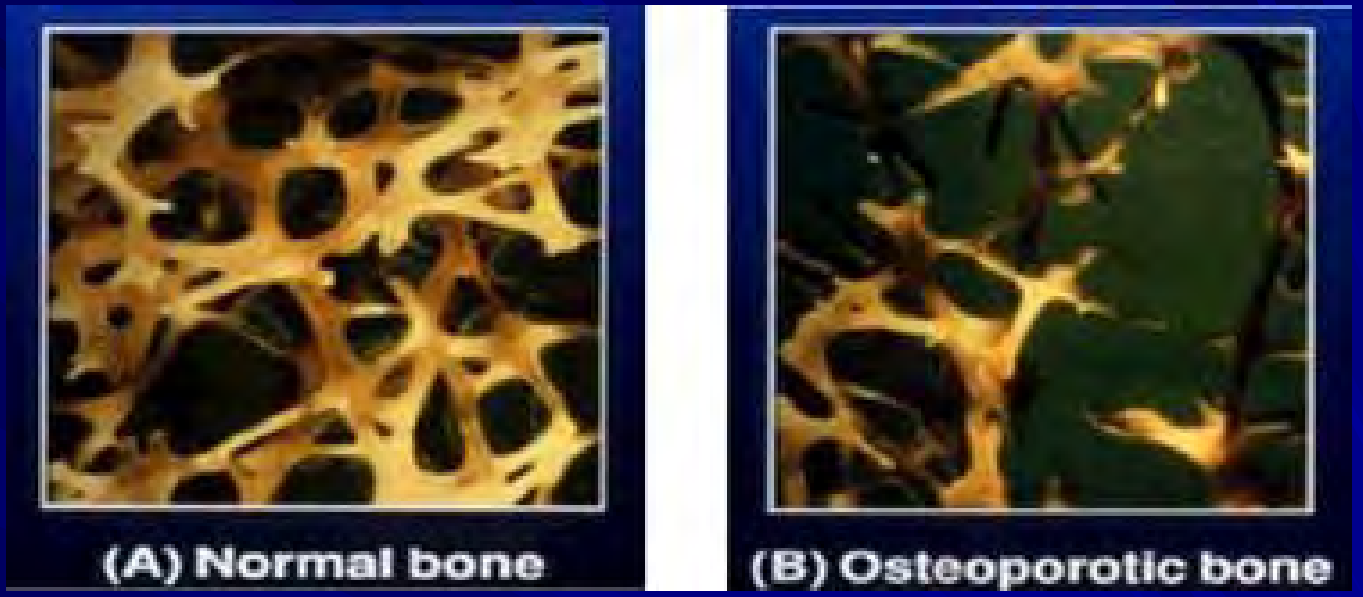
100 mm Hg

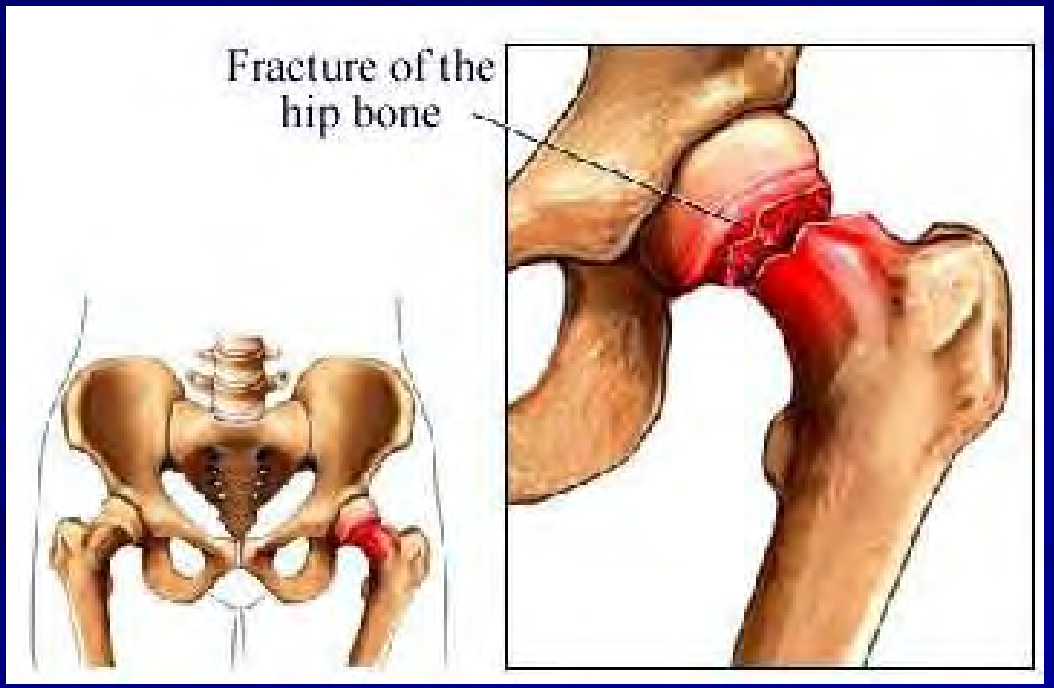
180 mm Hg



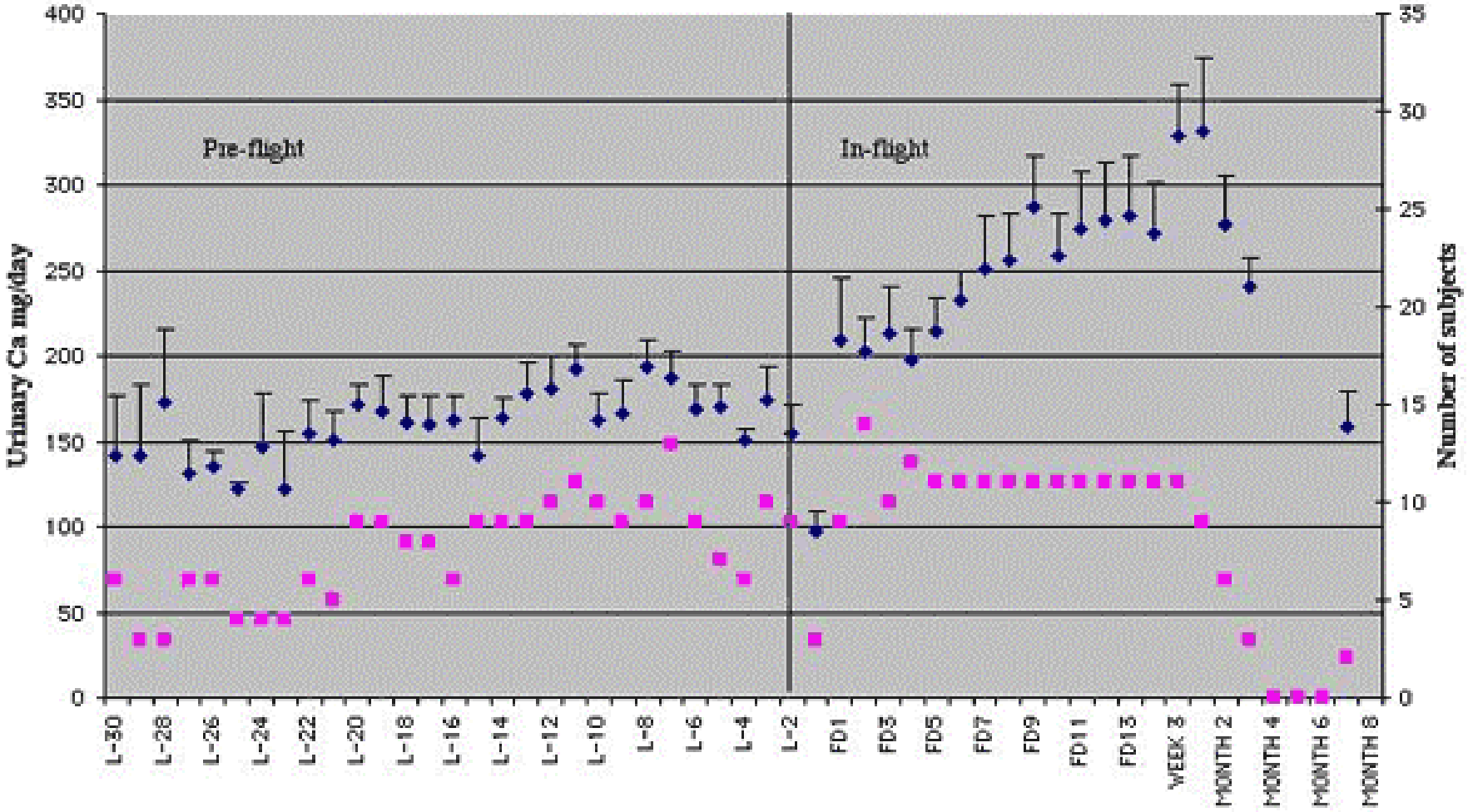

TOTAL BODY WATER
INTRACELLULAR FLUID
EXTRACELLULAR FLUID
PLASMA VOLUME
50 L
32 L
18 L
3 L
46 L
31 L
15 L
2.5 L
PREFLIGHT
WEIGHTLESSNESS
REENTRY
BLOOD DISTRIBUTION


Suppression
du poids du corps
Atrophie
musculaire
Atrophie
osseuse,
ostéoporose


(A) Normal bone
(B) Osteoporotic bone

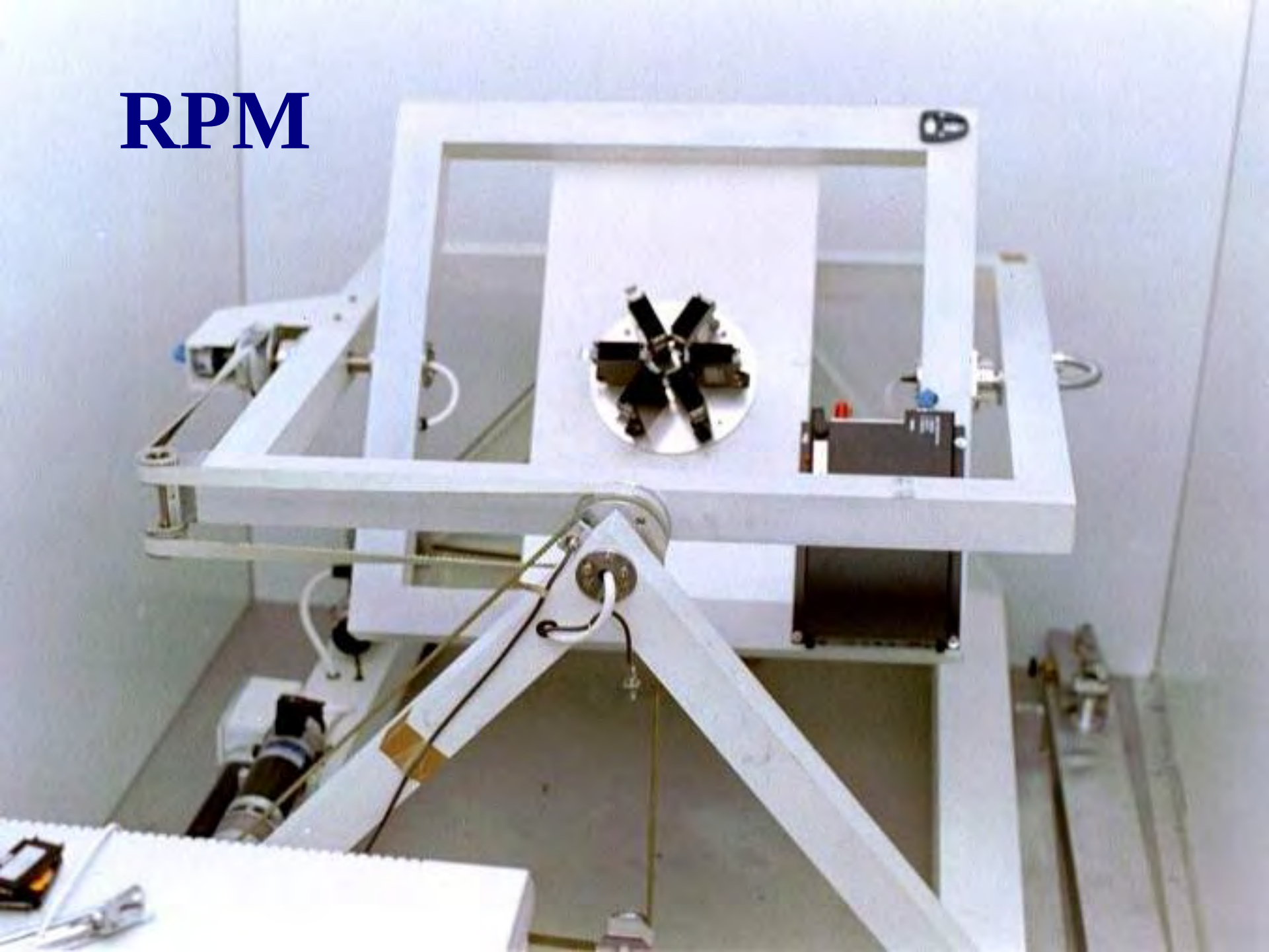

Fracture of the
hip bone

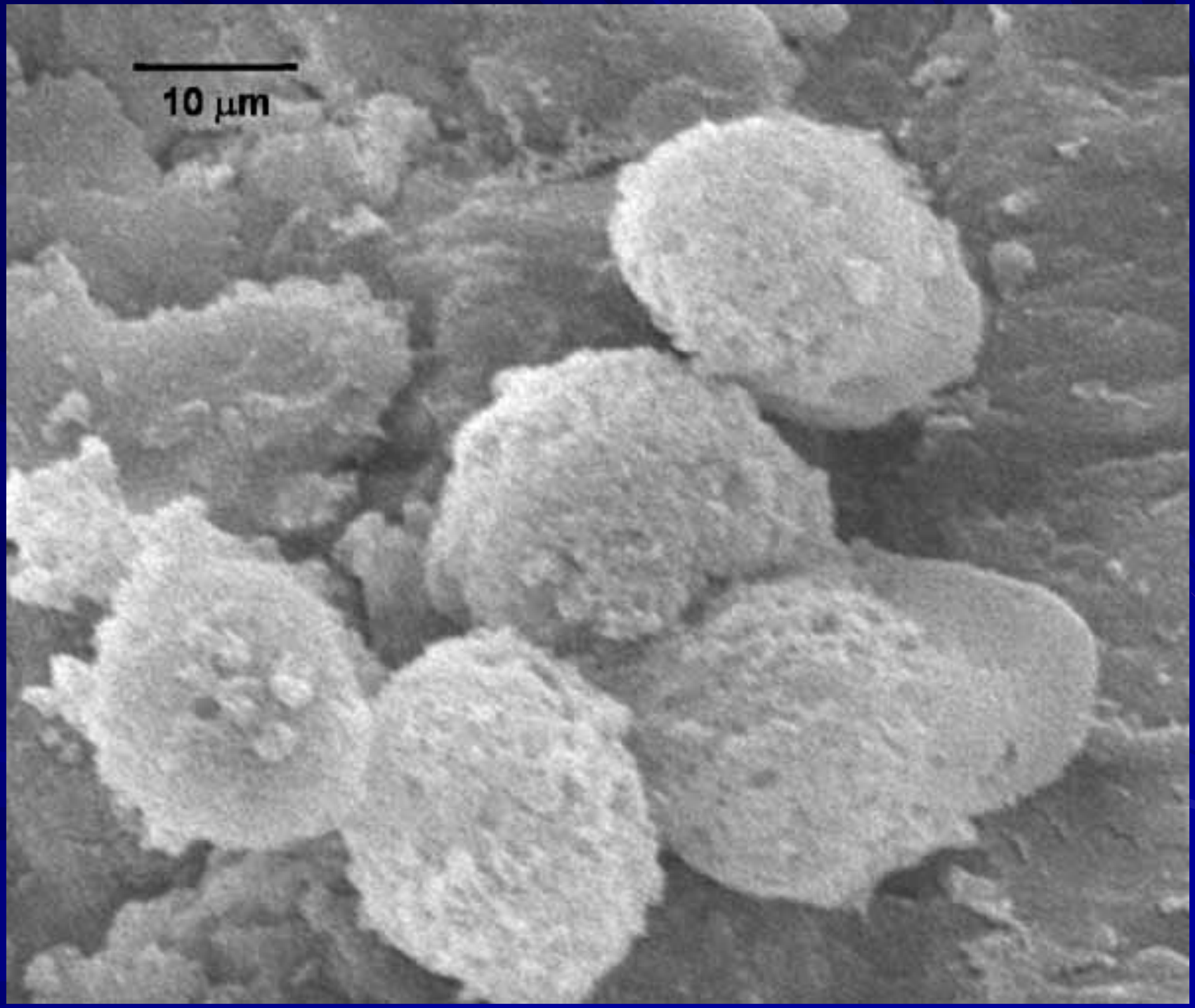
Mean Urinary Calcium in Space



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

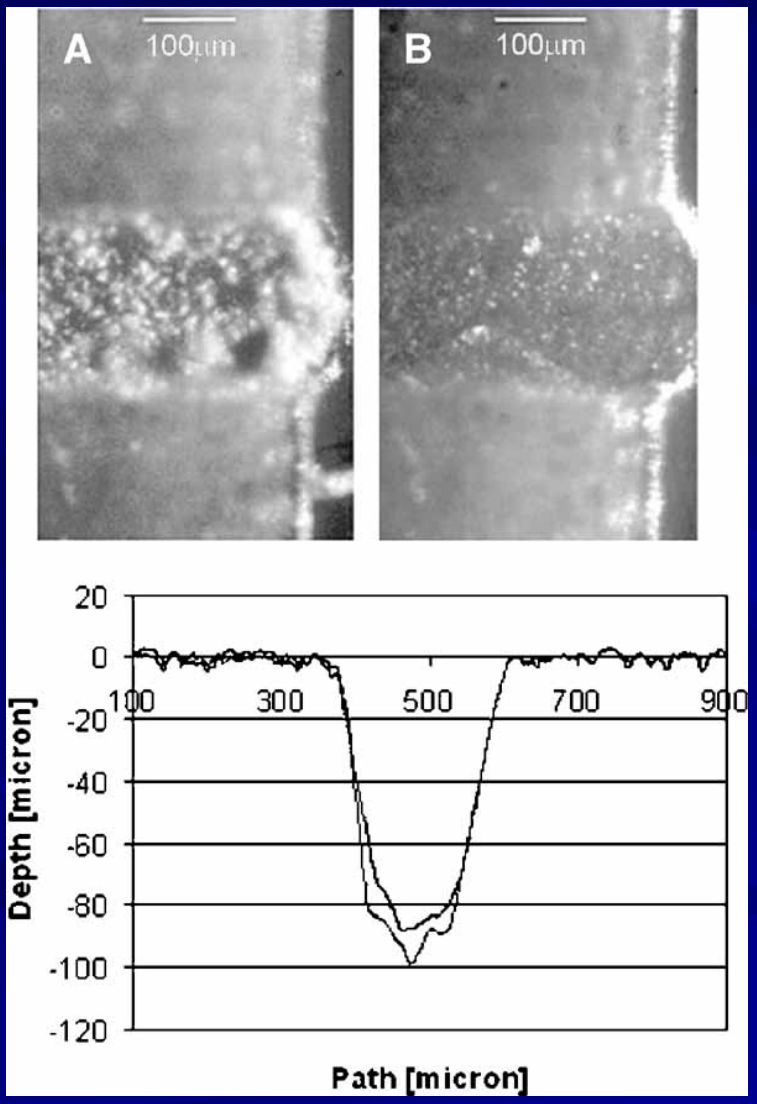
RPM




10 μm

0 g simulation, 72h

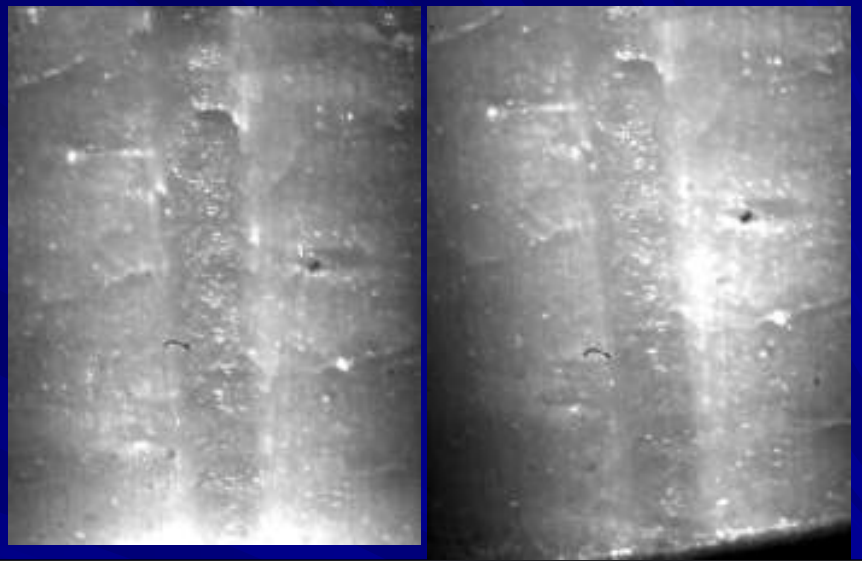
avant après

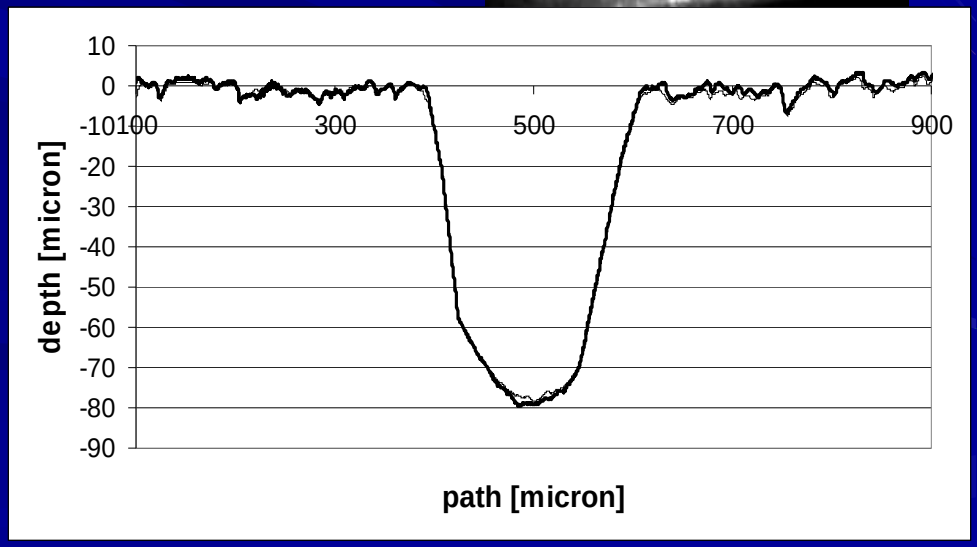


100 µm

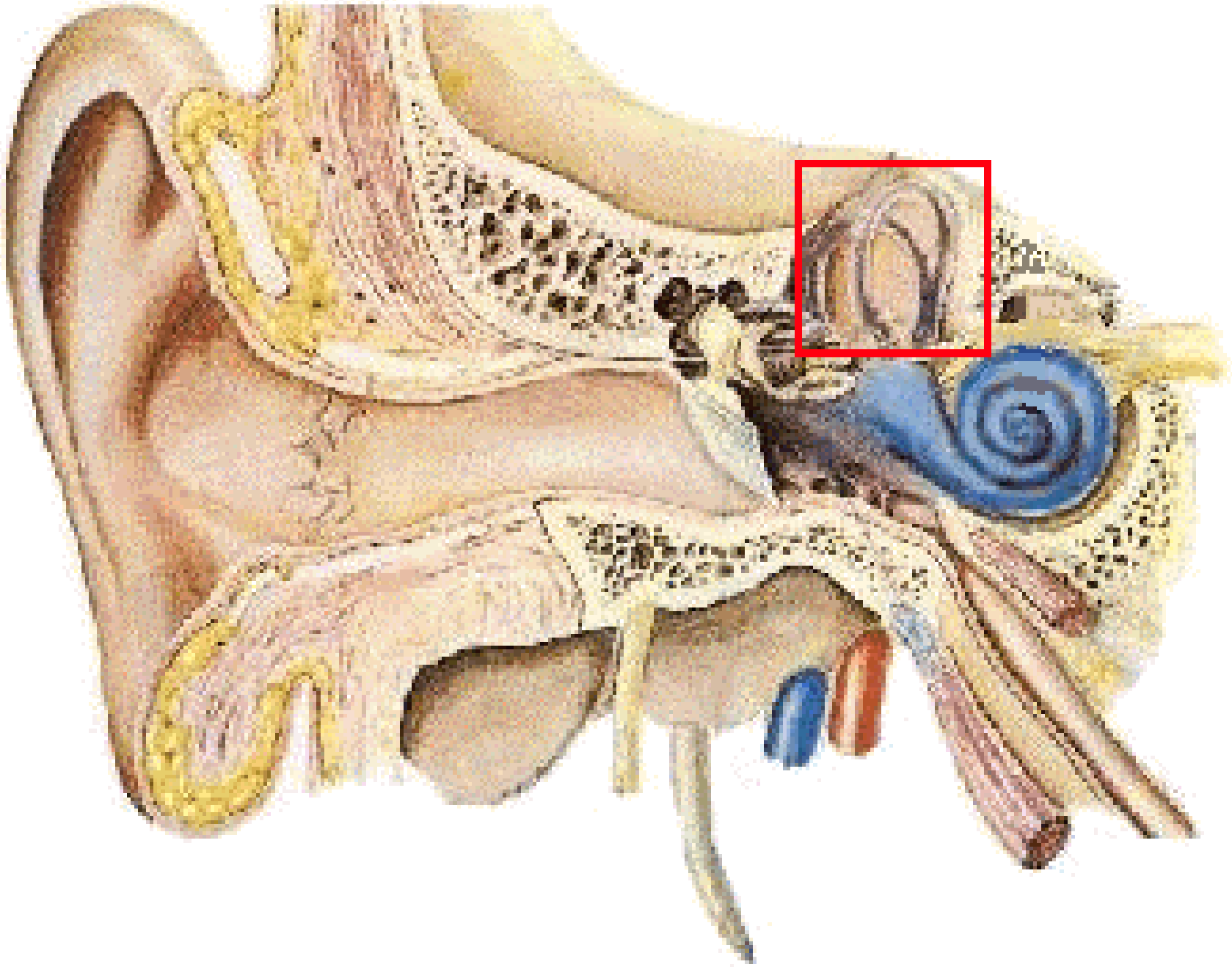
1 g contrôle, 72h

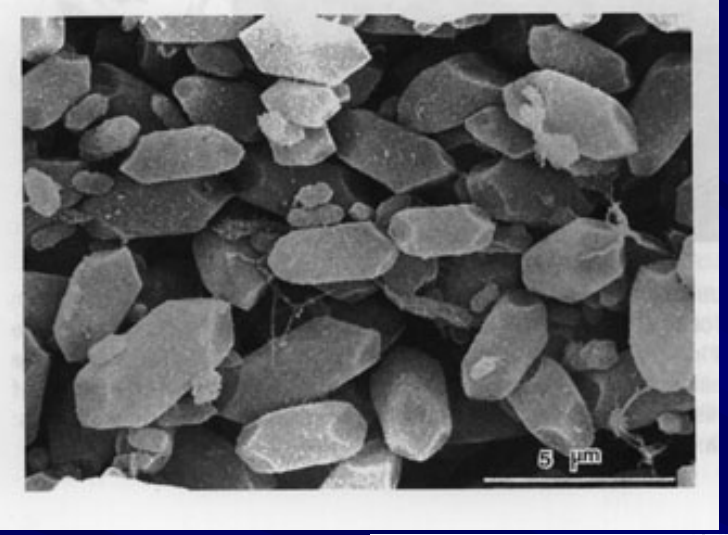
avant après



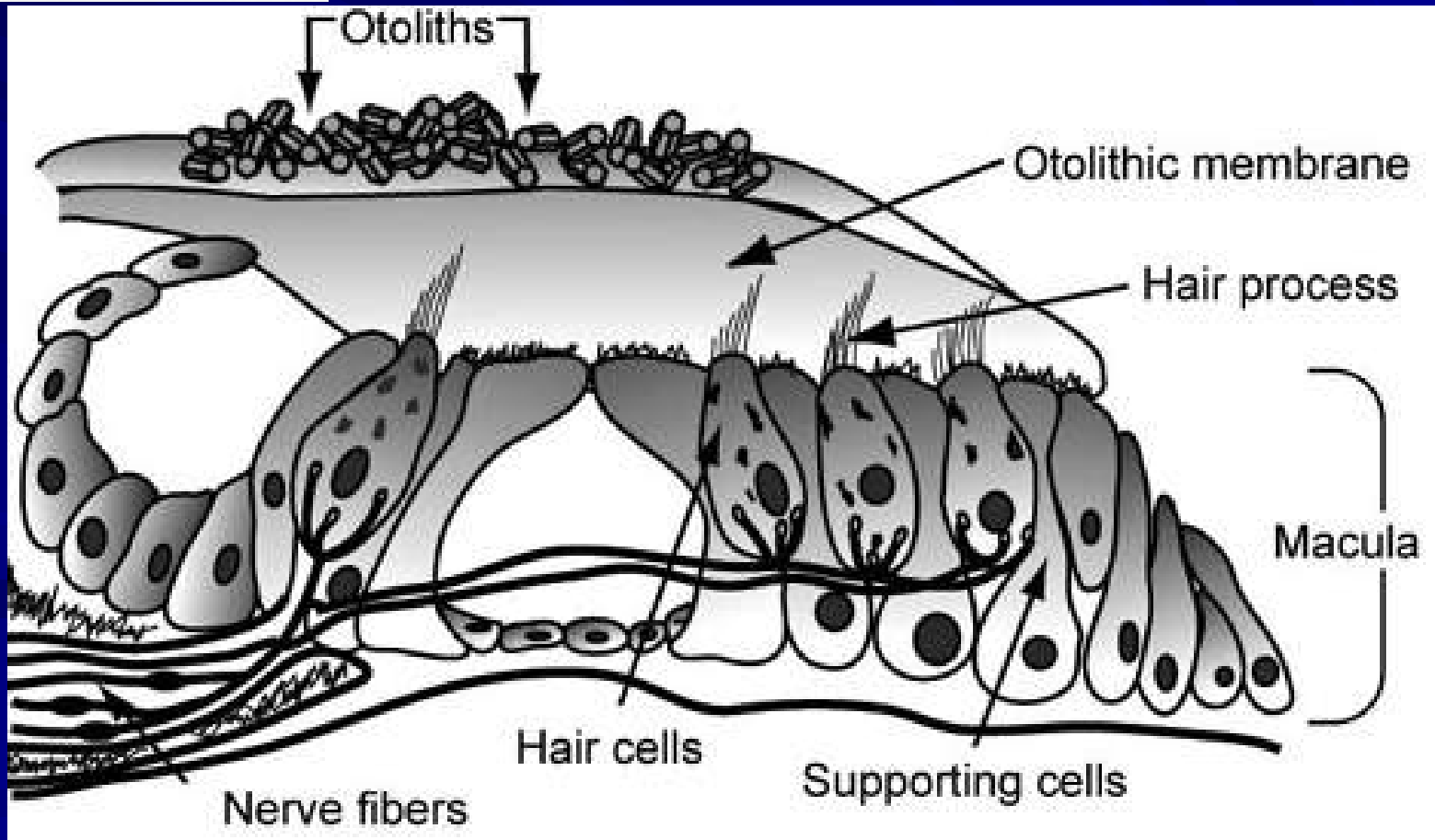


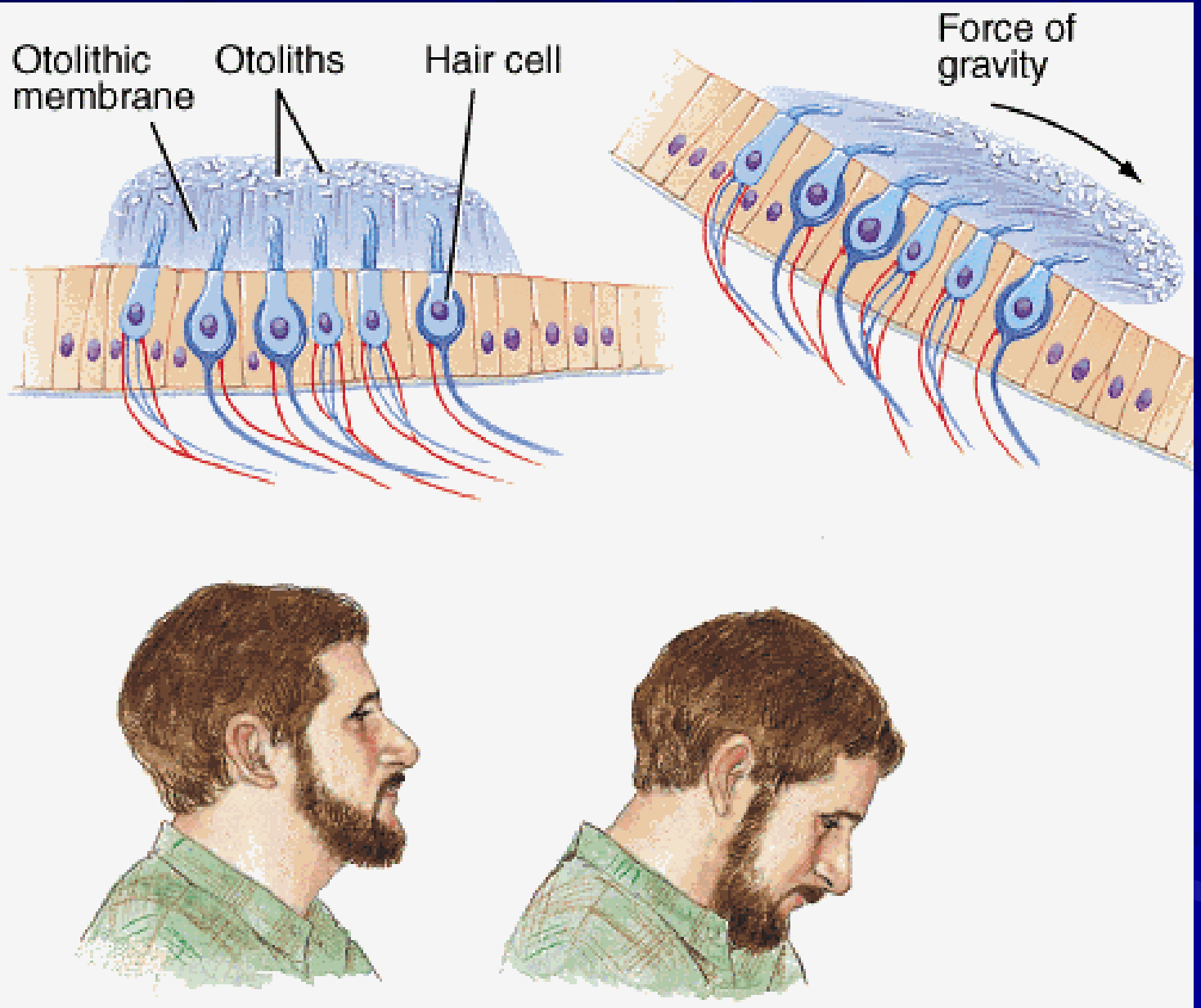
« Mal de l’espace »

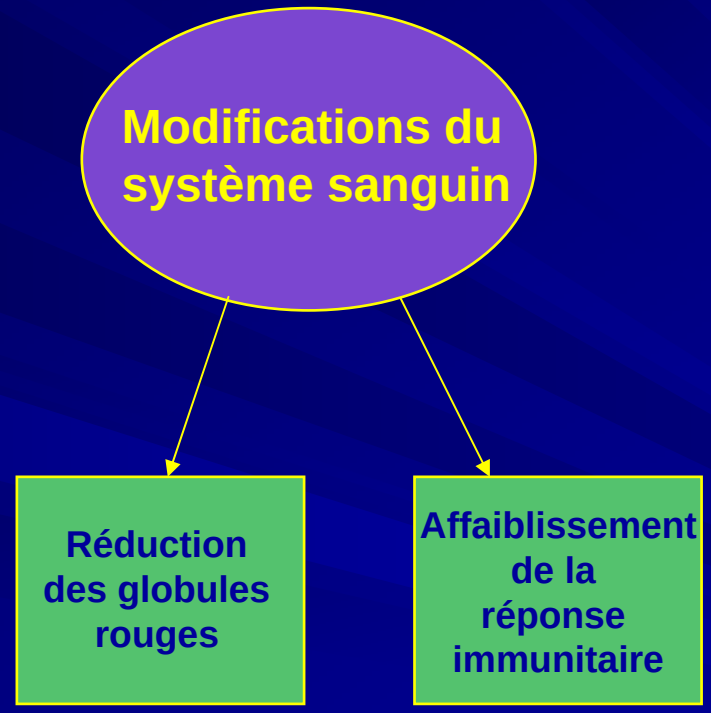


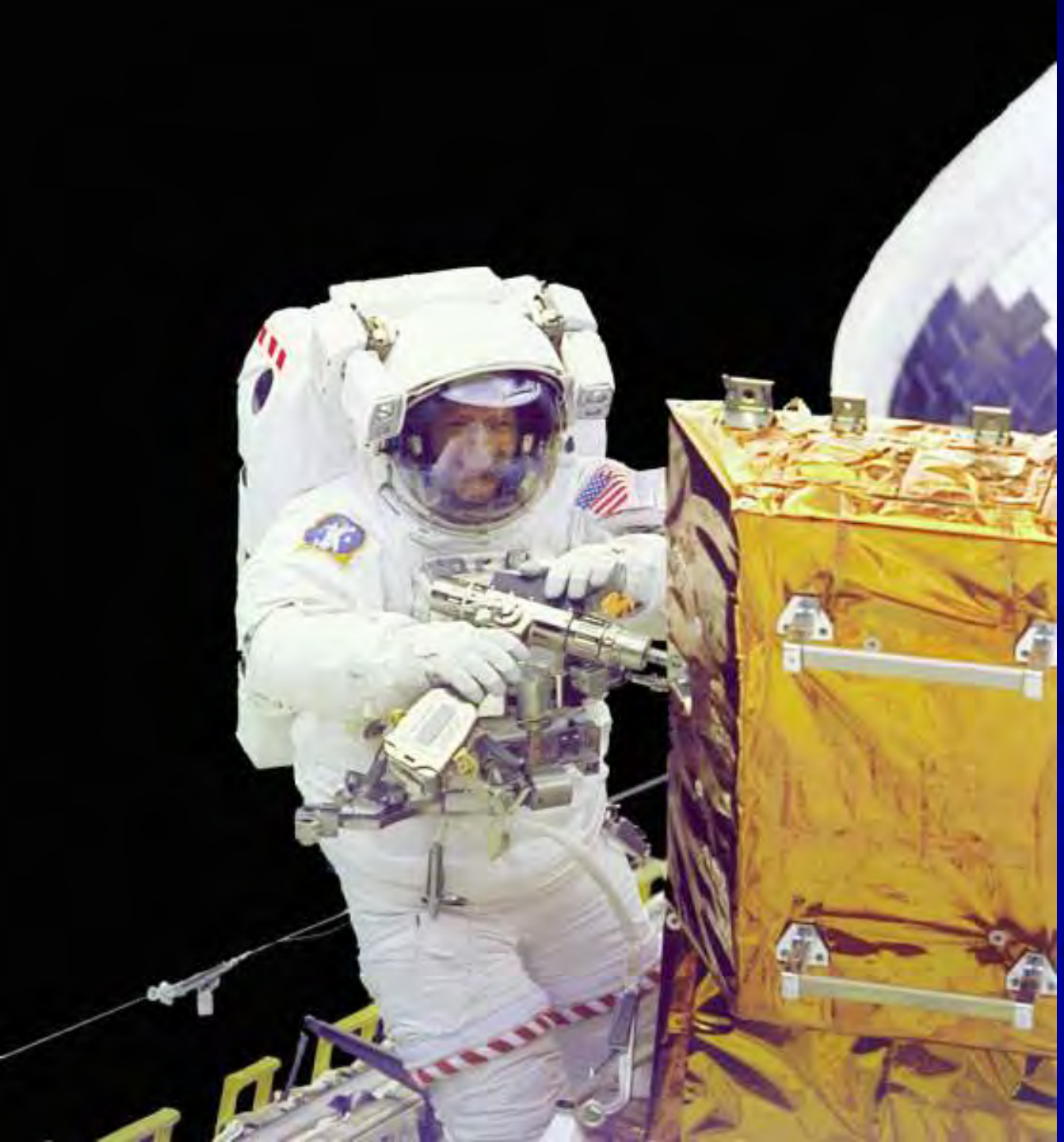


Otolithes $CaCO_3$

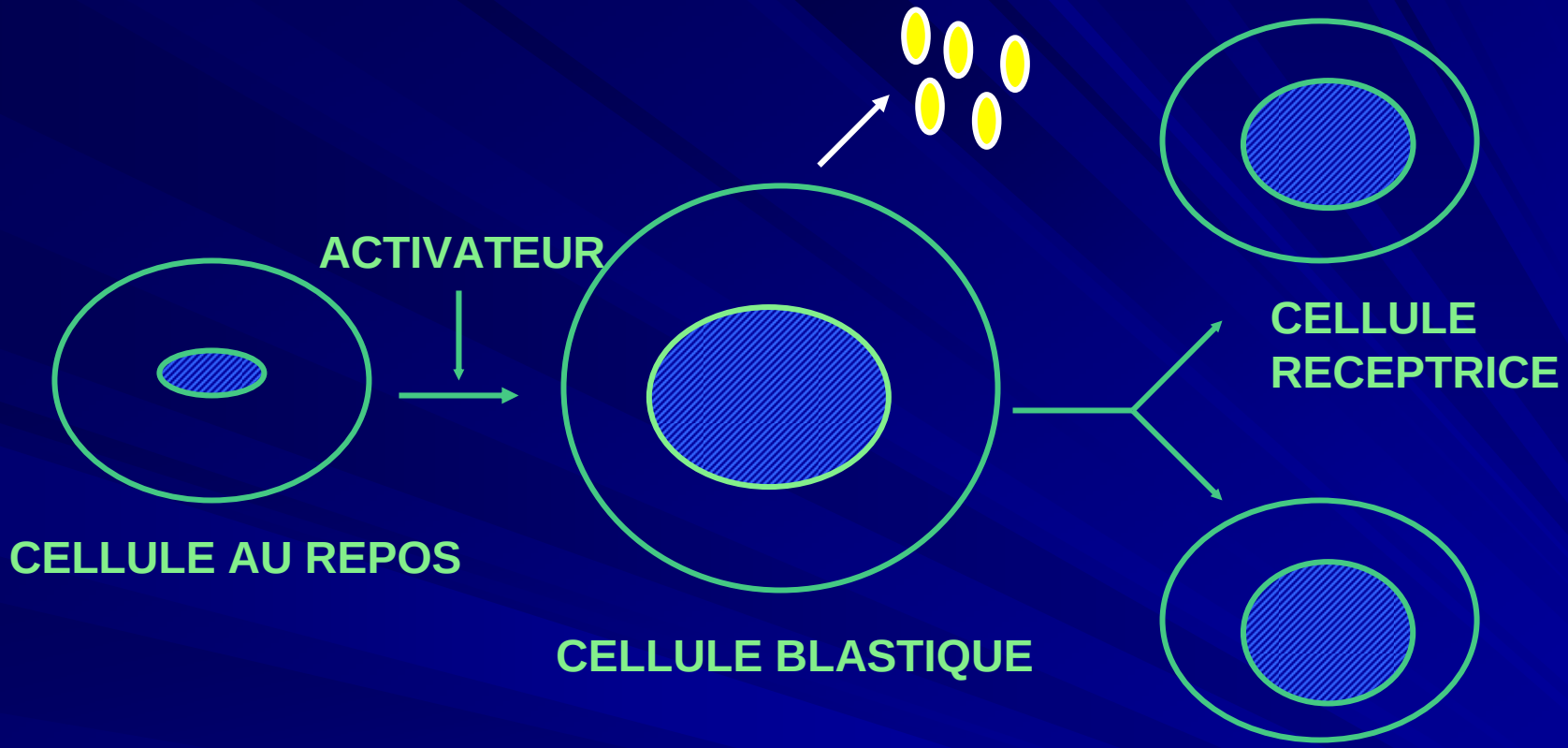



Otolithic membrane
Otoliths
Hair cell
Force of gravity
Head upright
Head tilted forward


Modifications du système sanguin
Réduction des globules rouges
Affaiblissement de la réponse immunitaire

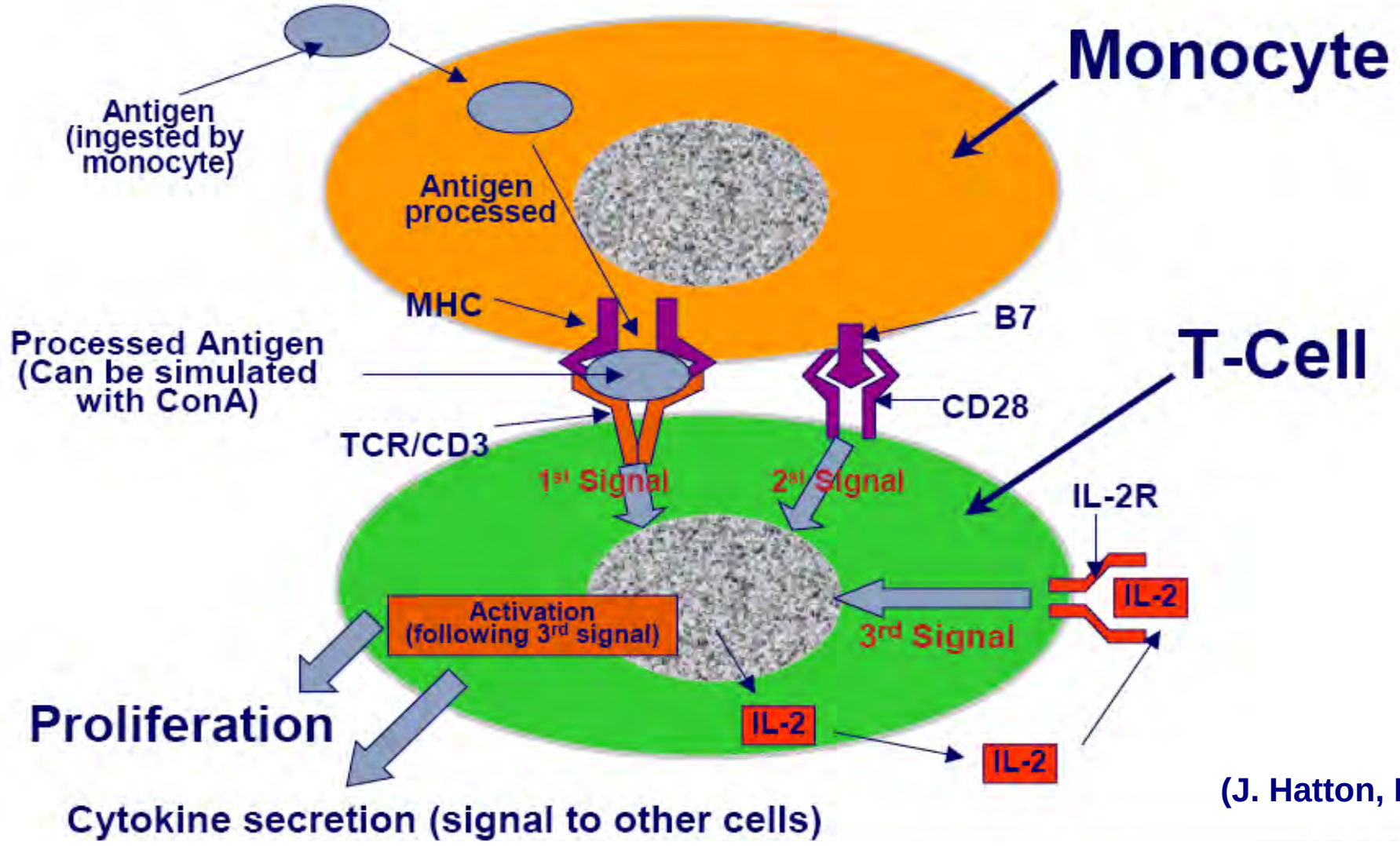


Claude Nicollier
STS-103
19 - 27 décembre 1999
Réparation du télescope Hubble



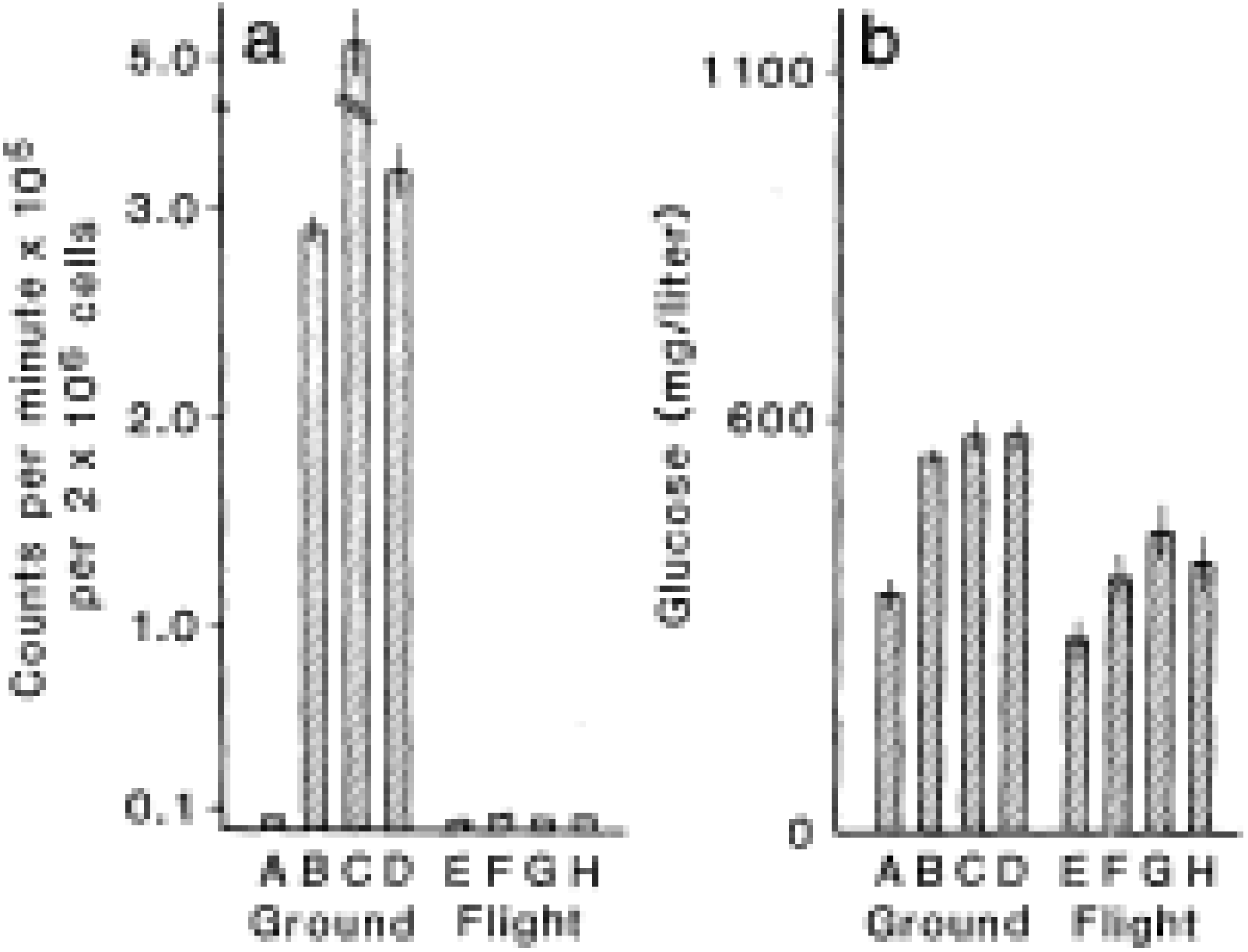
ACTIVATION DE LYMPHOCYTES T

DELIVERY OF SECOND SIGNAL

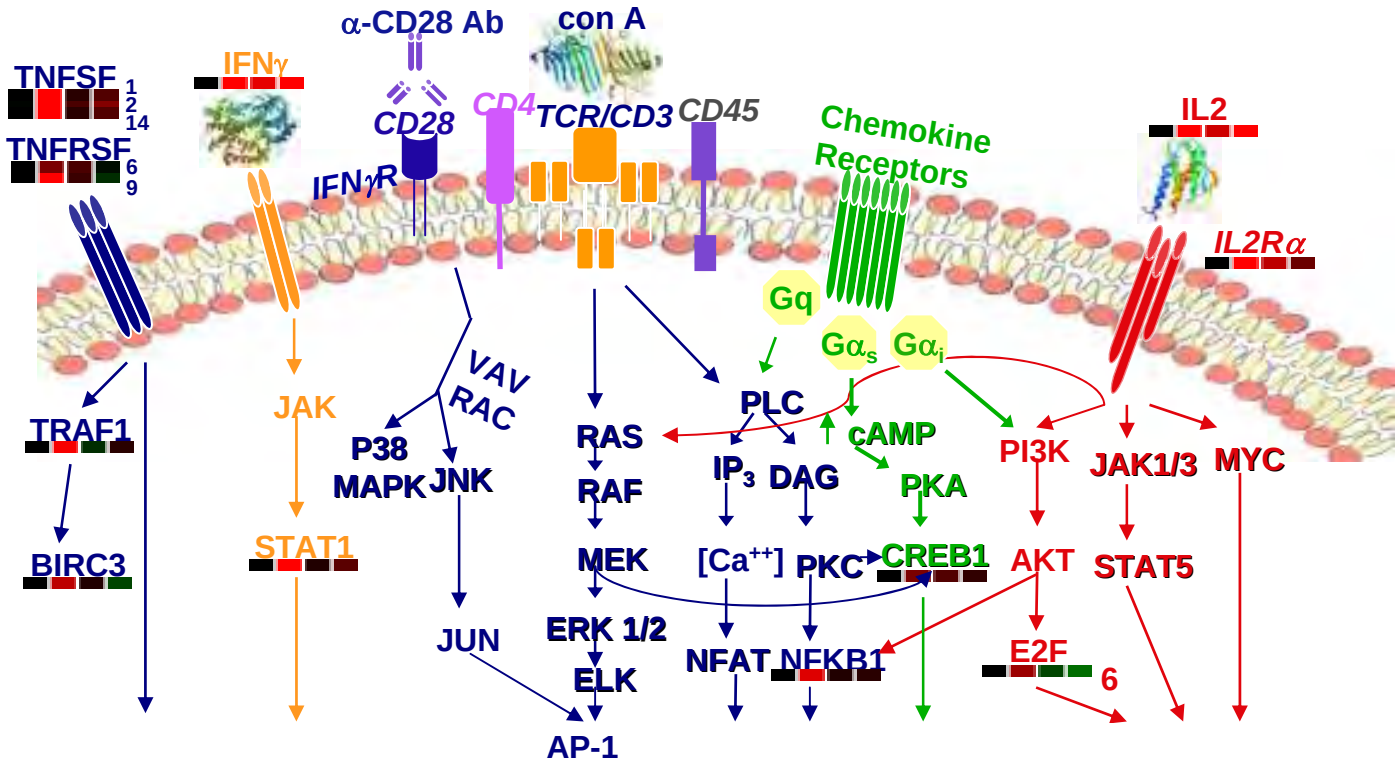


(J. Hatton, ESA)

Cogoli et al., Science, 225: 228-30, 1984

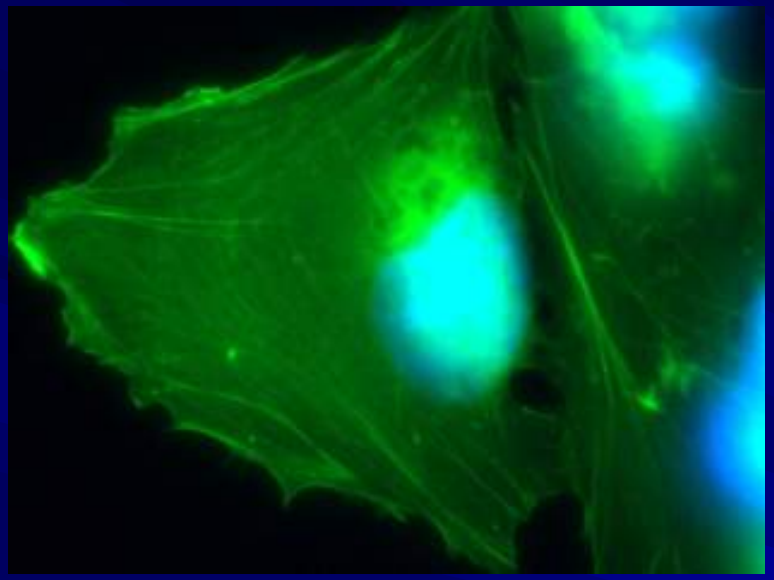


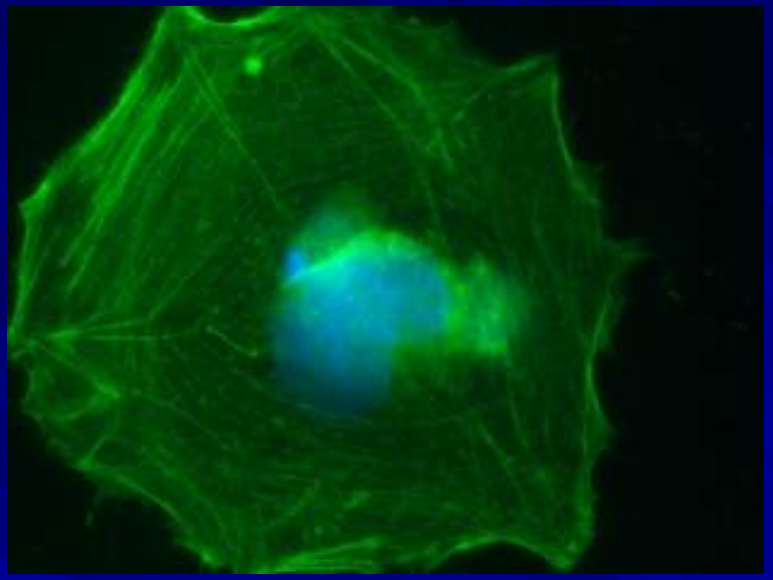
Signaling Pathways Involved in T-cell Activation



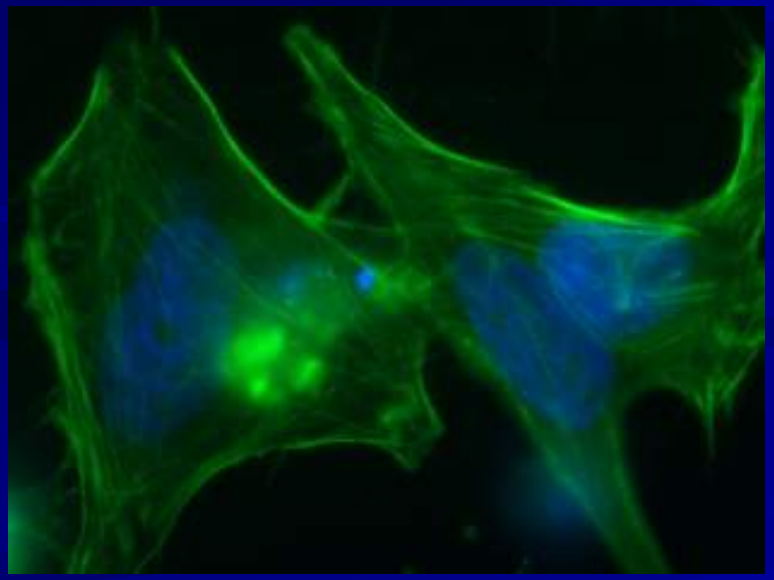
F- ACTIN IN J-111 CELLS IN KUBIK

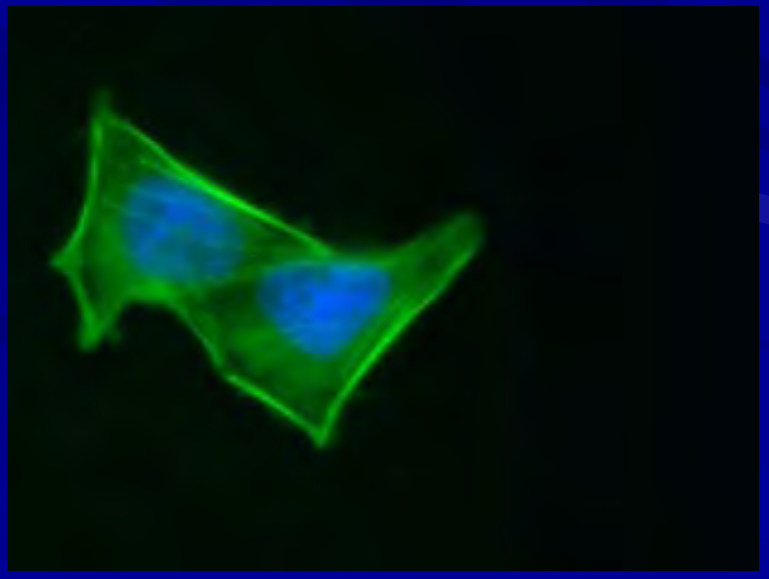
Pani, Saba, Meloni, Galleri, M. Cogoli





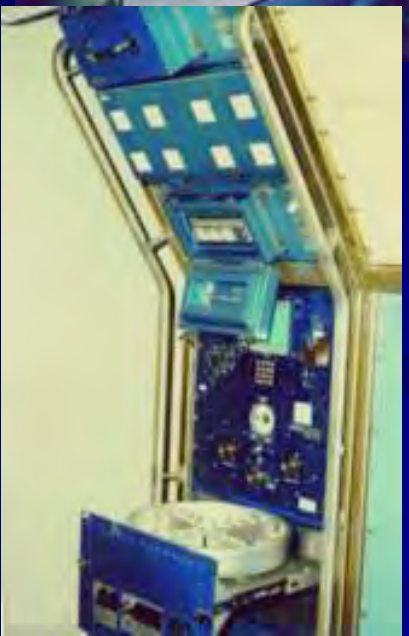
1 G





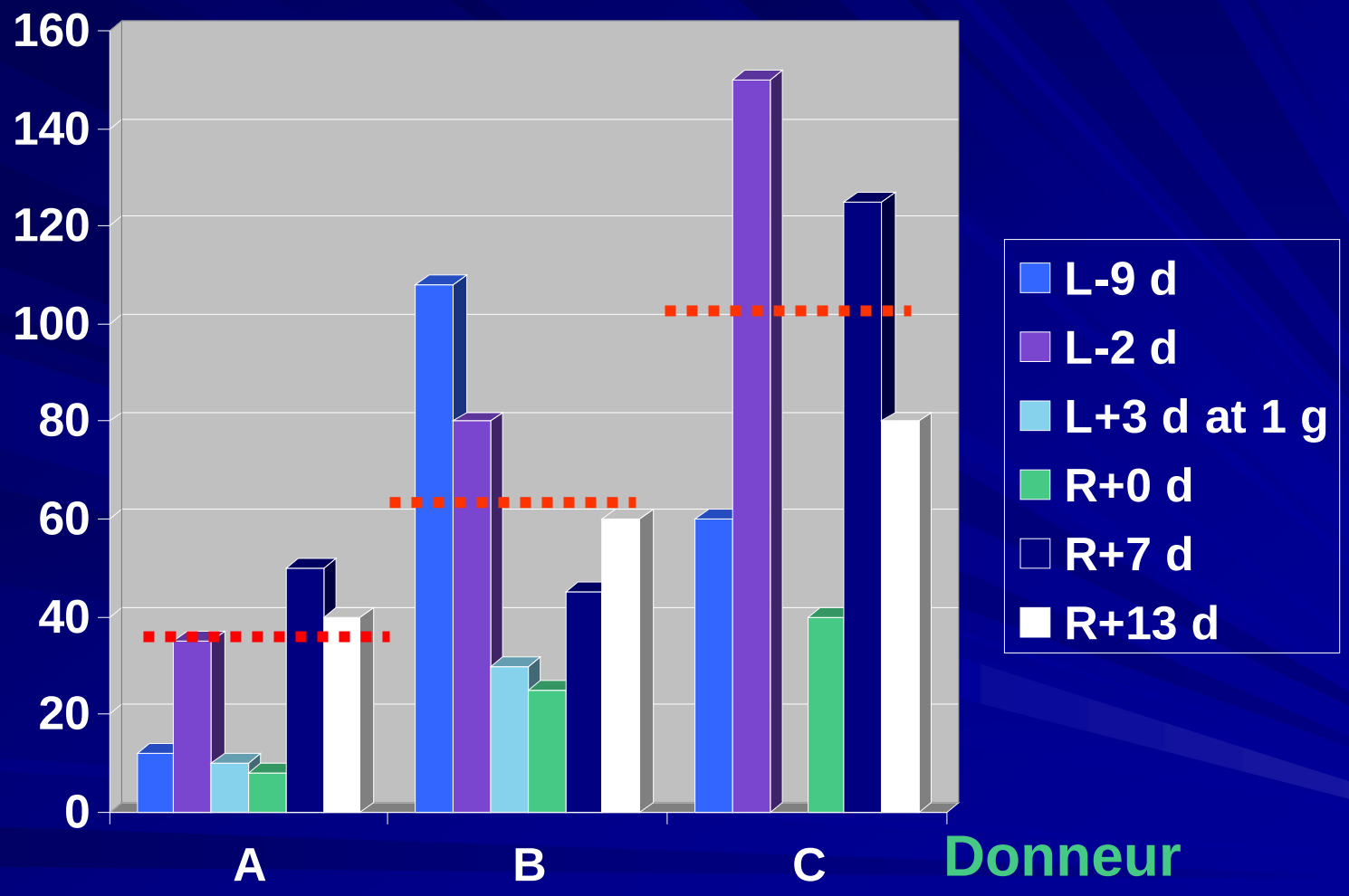
0 G

Kit de prélèvement sanguin « maison » pour Spacelab

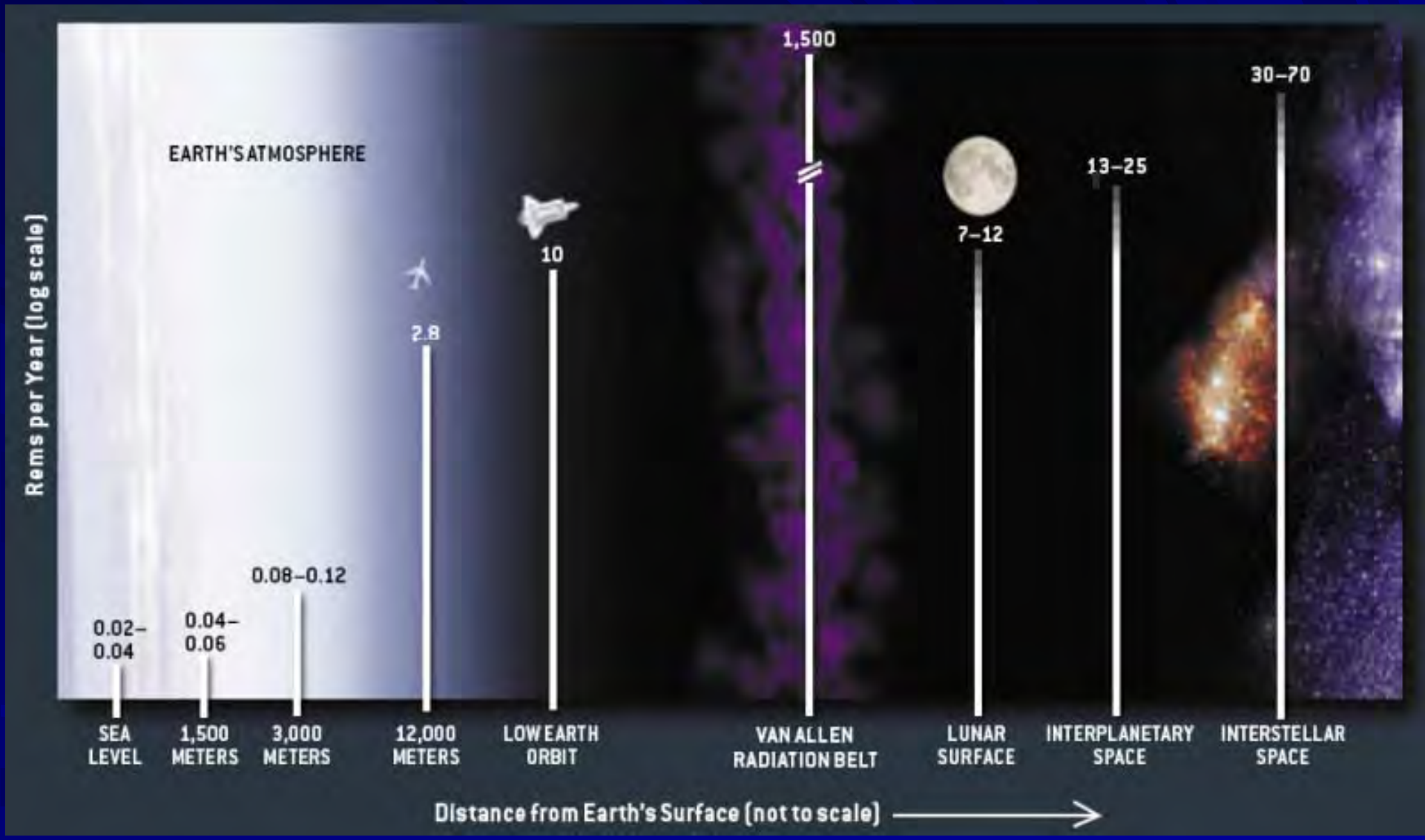


Mission Spacelab Life Science-1, 1991

Prélèvement sanguin après le vol au KSC


160
140
120
100
80
60
40
20
0
A
B
C
Donneur
L-9 d
L-2 d
L+3 d at 1 g
R+0 d
R+7 d
R+13 d

Rayonnement cosmique


EARTH'S ATMOSPHERE
Rems per Year (log scale)
0.02–0.04
0.04–0.06
0.08–0.12
2.8
10
1,500
7–12
13–25
30–70
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)

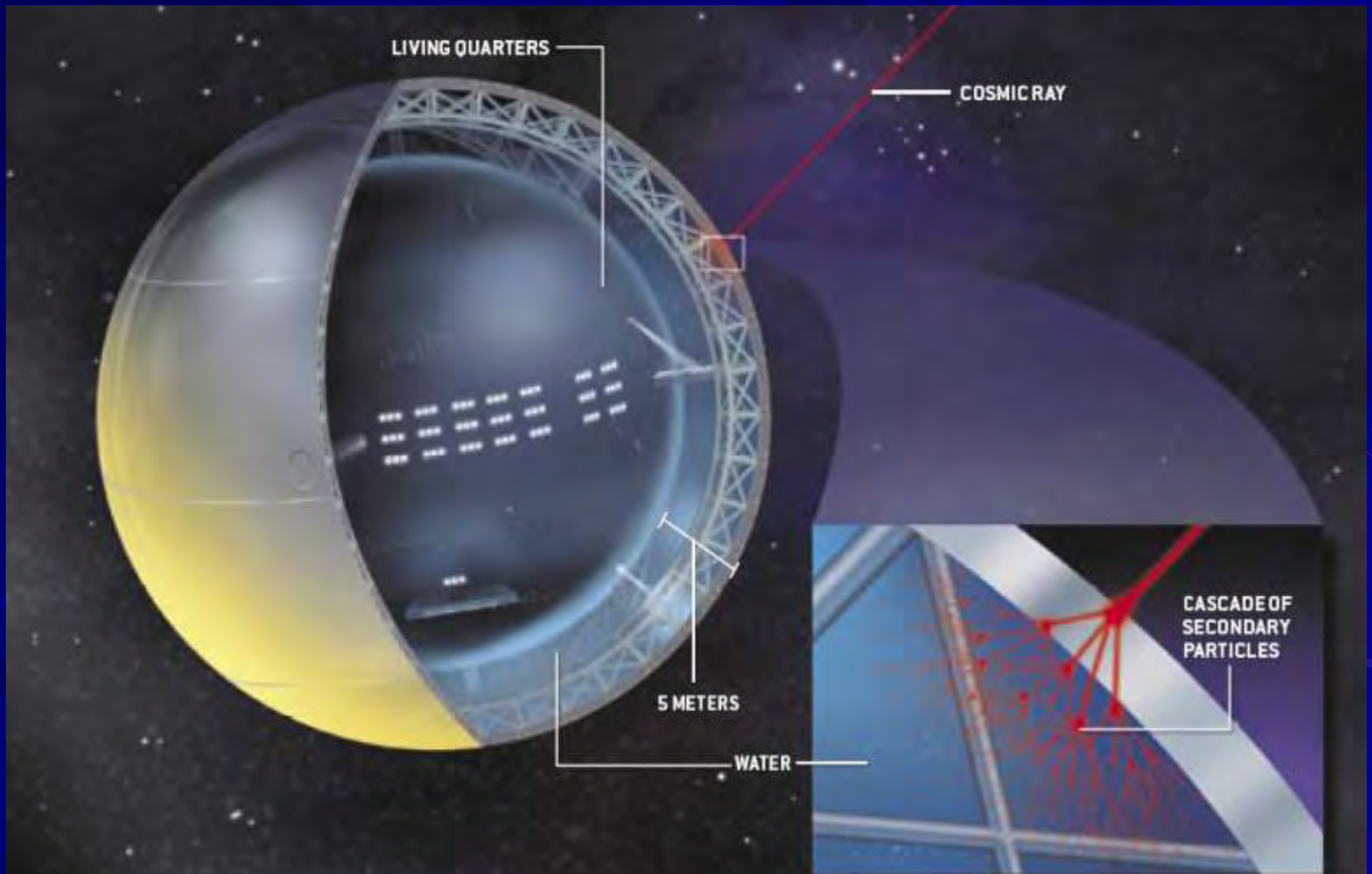
Avantage:

- sûr et fiable

Plan 1: Bouclier d'eau

Inconvénient:

- beaucoup trop lourd



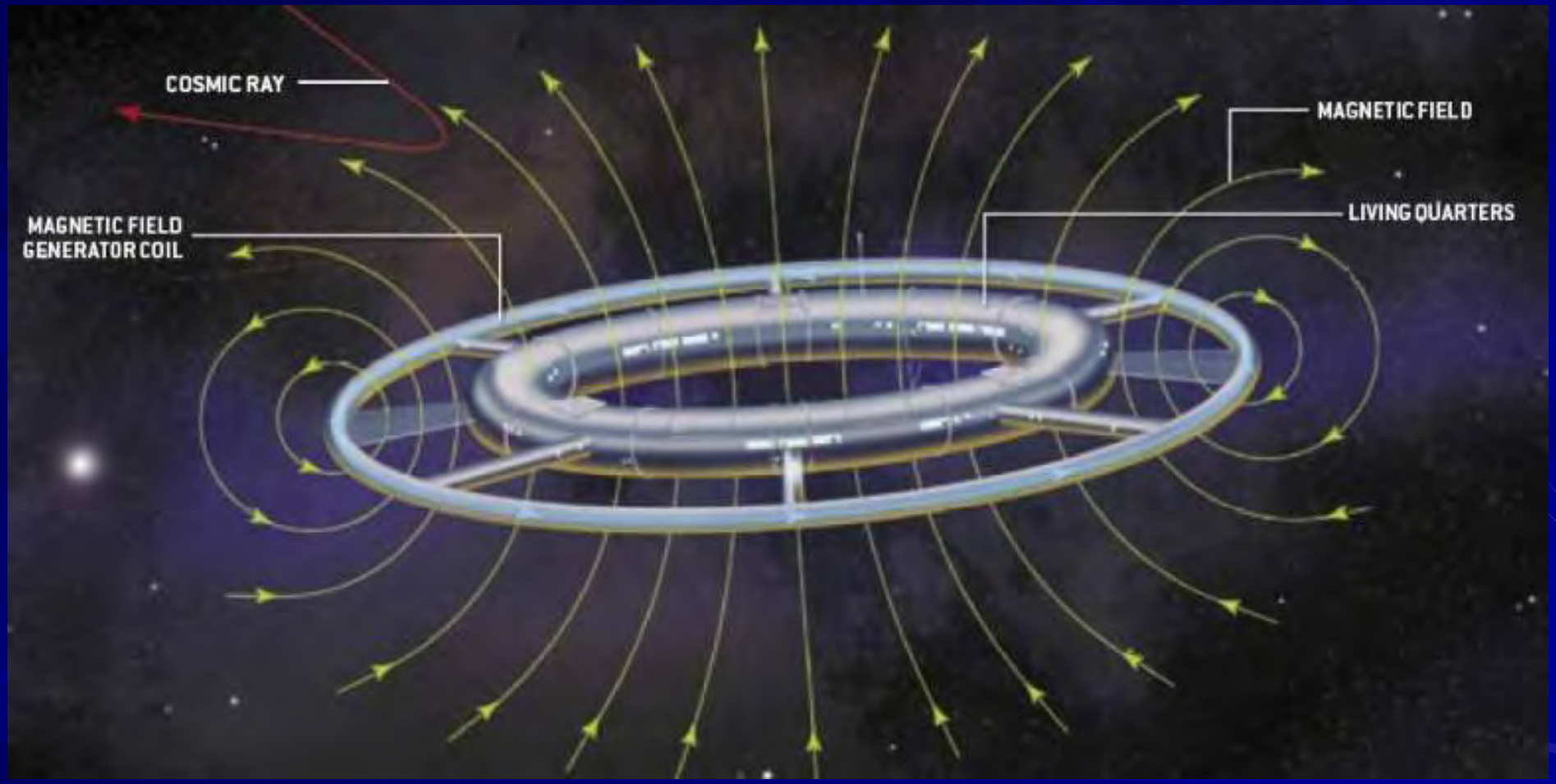
Avantage :

- beaucoup plus léger que le bouclier d'eau

Plan 2: Bouclier magnétique

Inconvénients:

- champ magnétique trop fort
- atteintes à la santé



Plan 3: Bouclier électrostatique

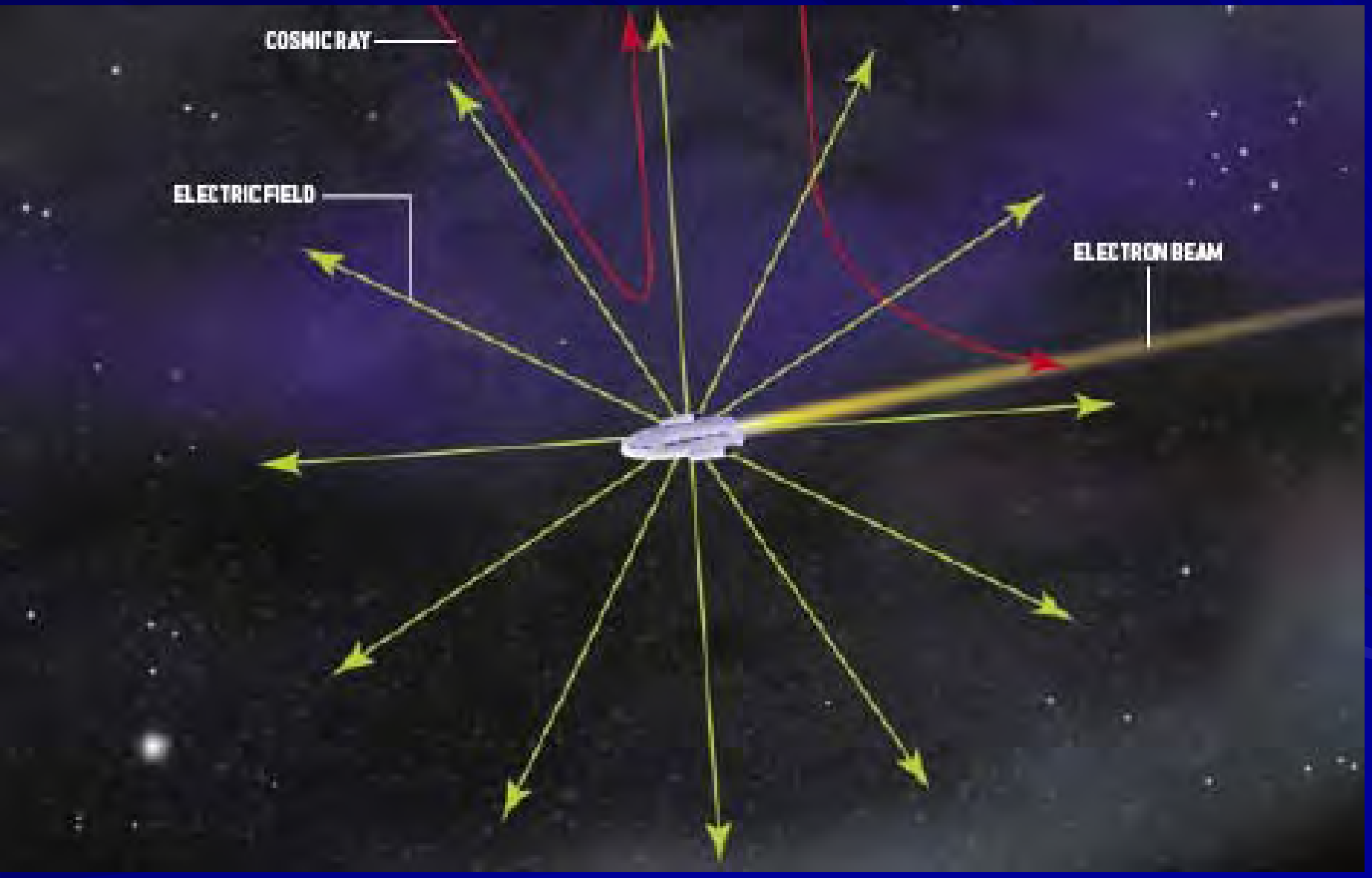
Avantages:

- léger

- pas d'atteinte à la santé

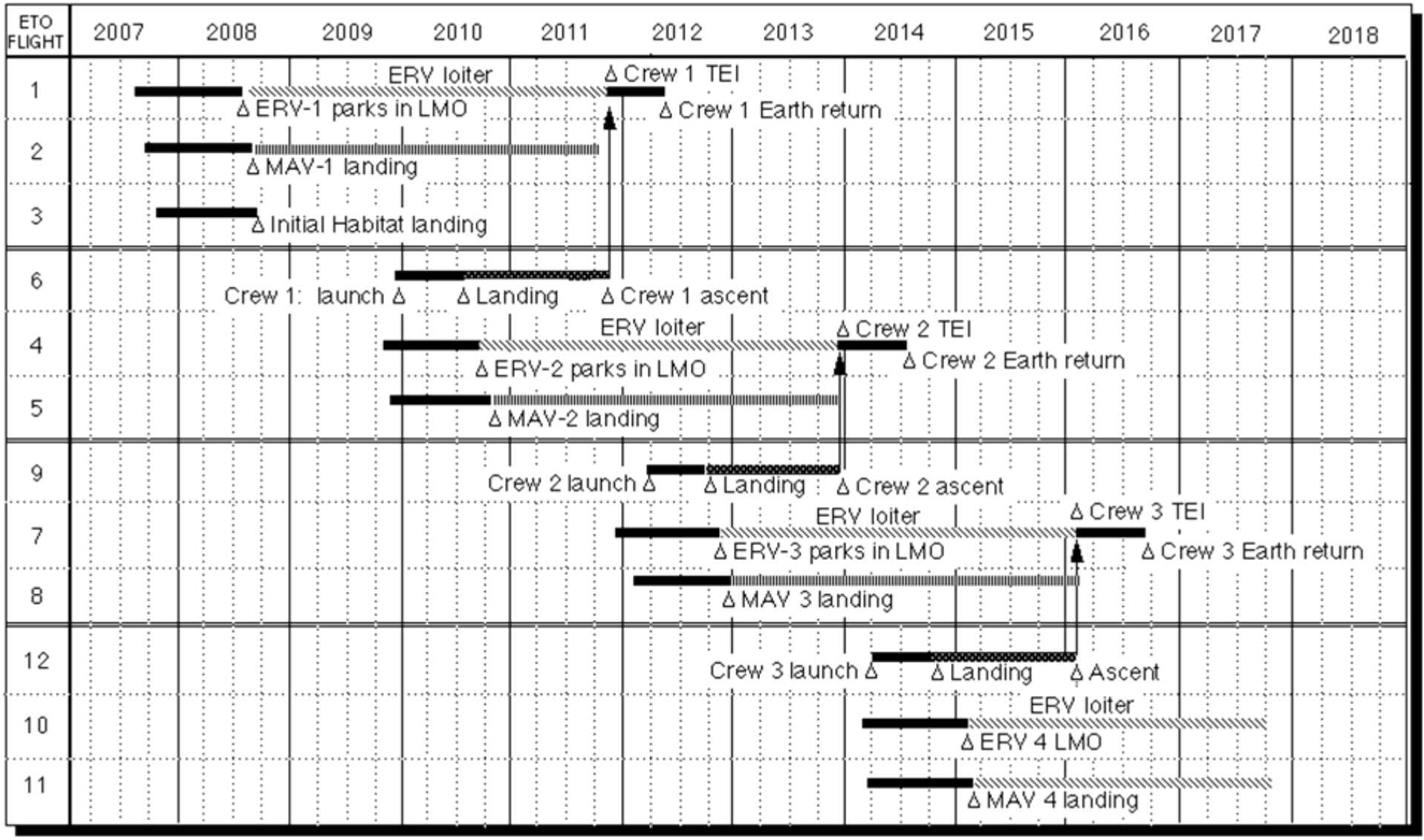
Inconvénient **:**

- nécessite d'immenses quantités d'électricité

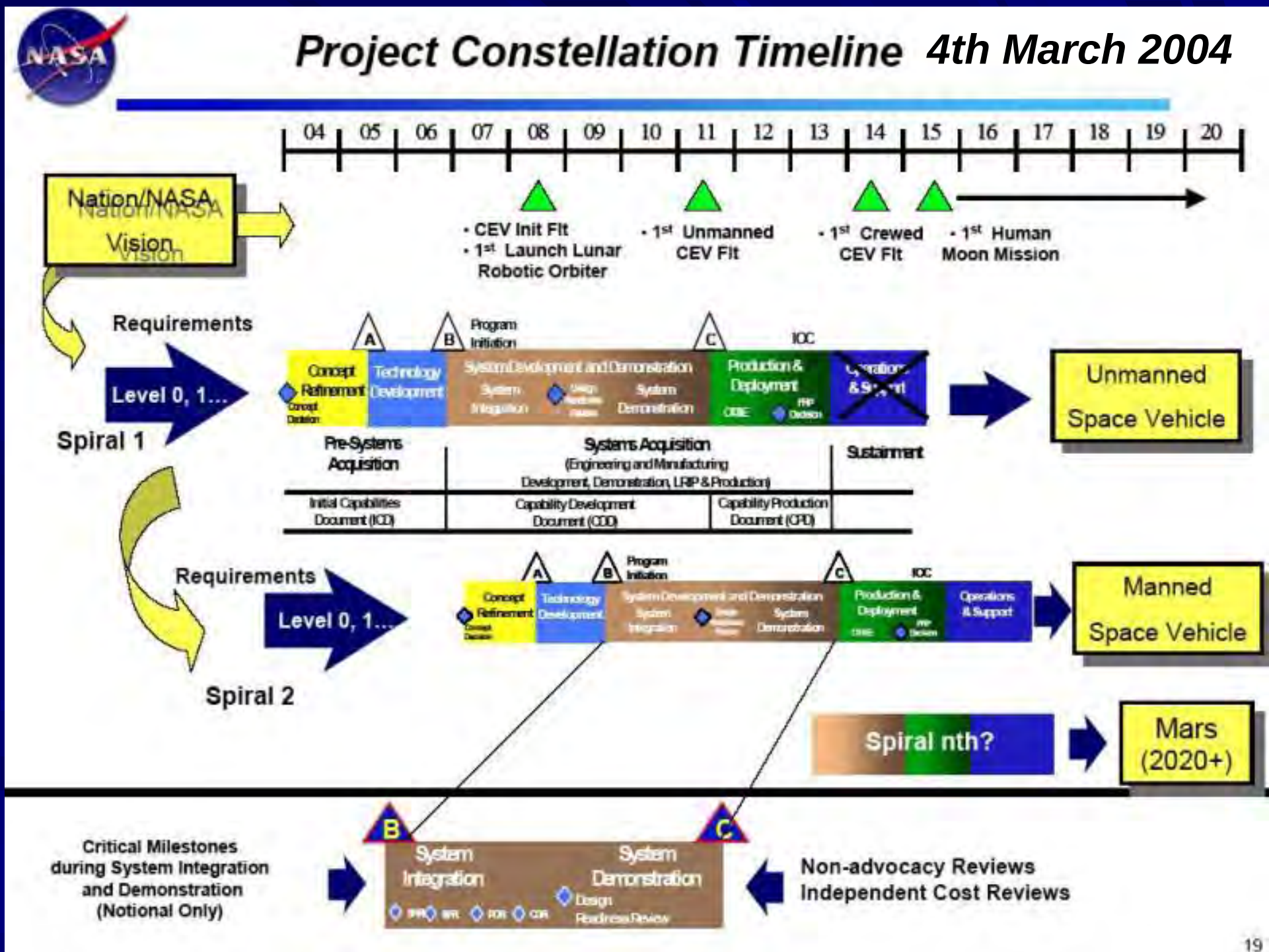


2. La mission Mars

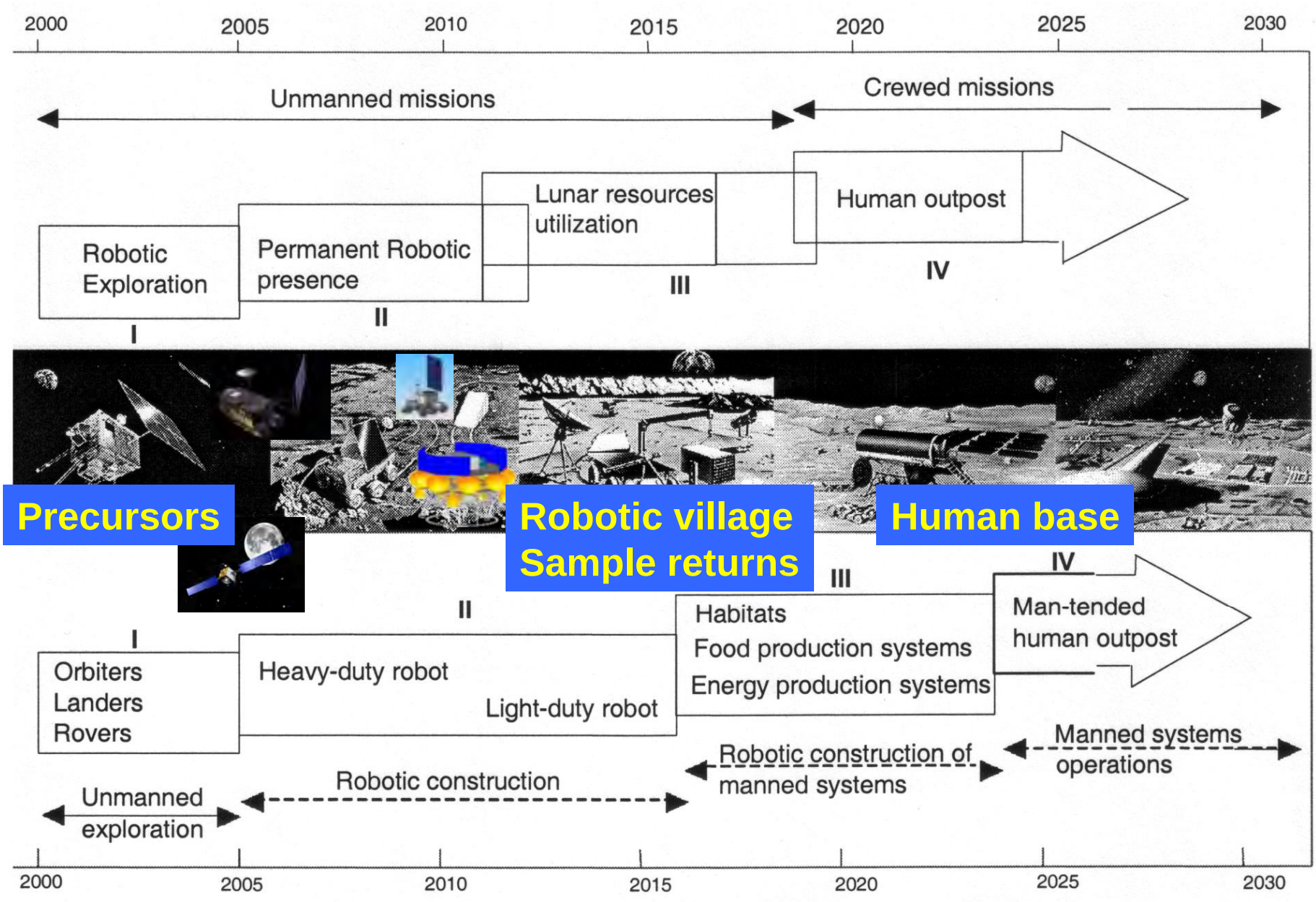
Echéancier de la NASA, années 90



Project Constellation Timeline 4th March 2004



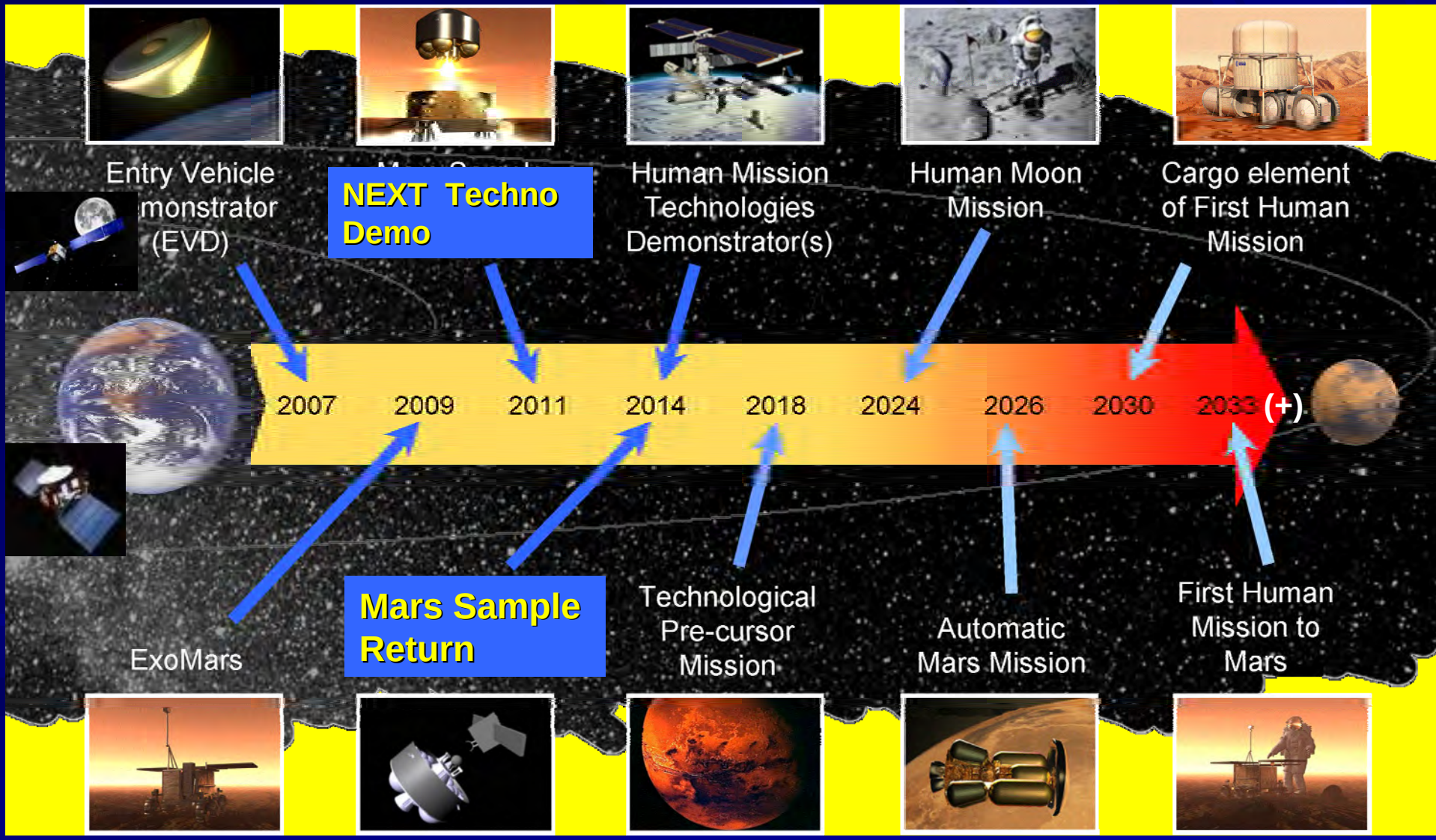
Echéancier de l'exploration lunaire internationale, 2007



EXPLORATION AU-DELA DE L'ORBITE BASSE TERRESTRE

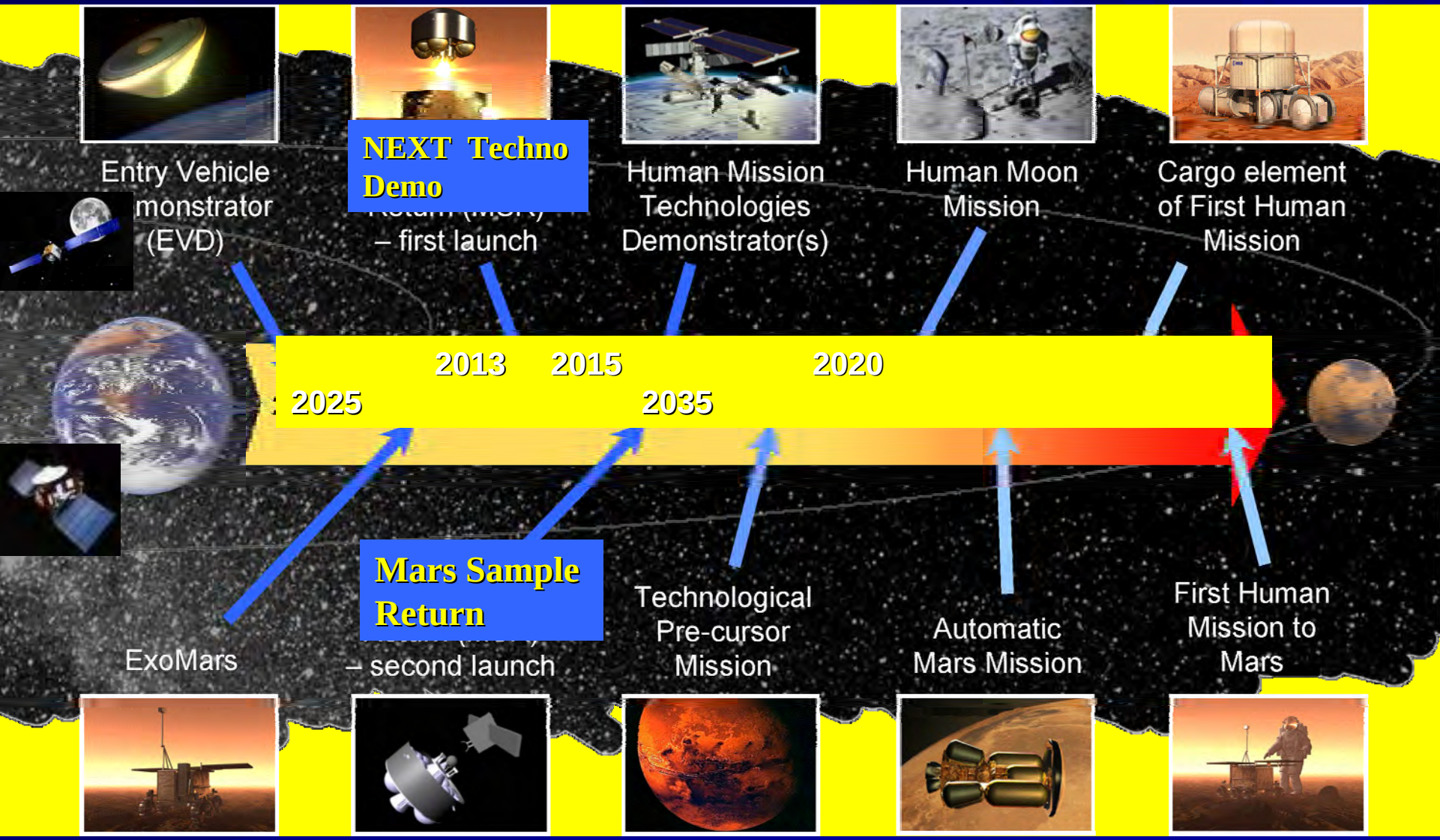
Echéancier de l'exploration Lune-Mars

Programme Aurora, 2001



Echéancier revu de l'exploration Lune-Mars

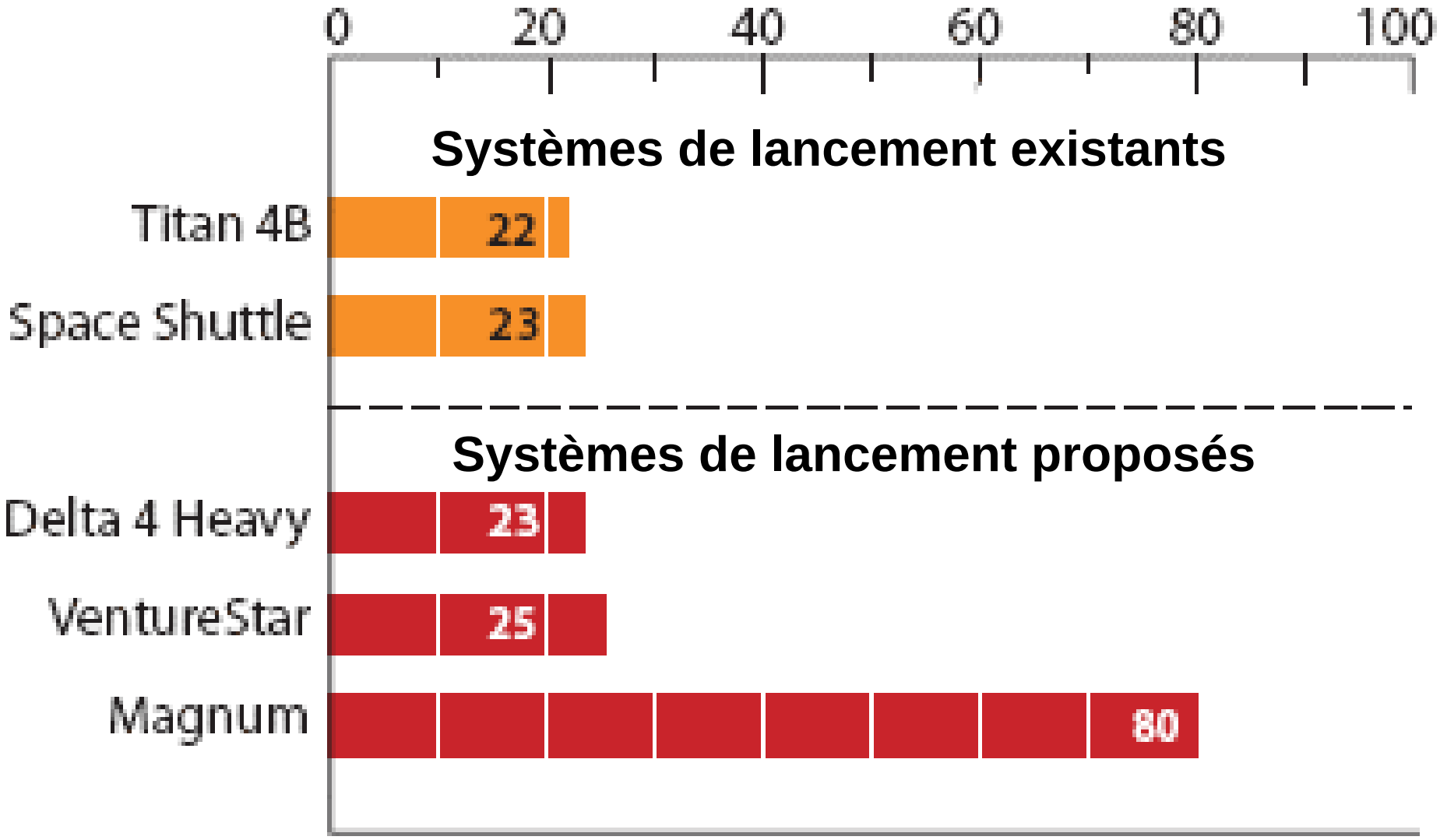
Programme Aurora, 2007

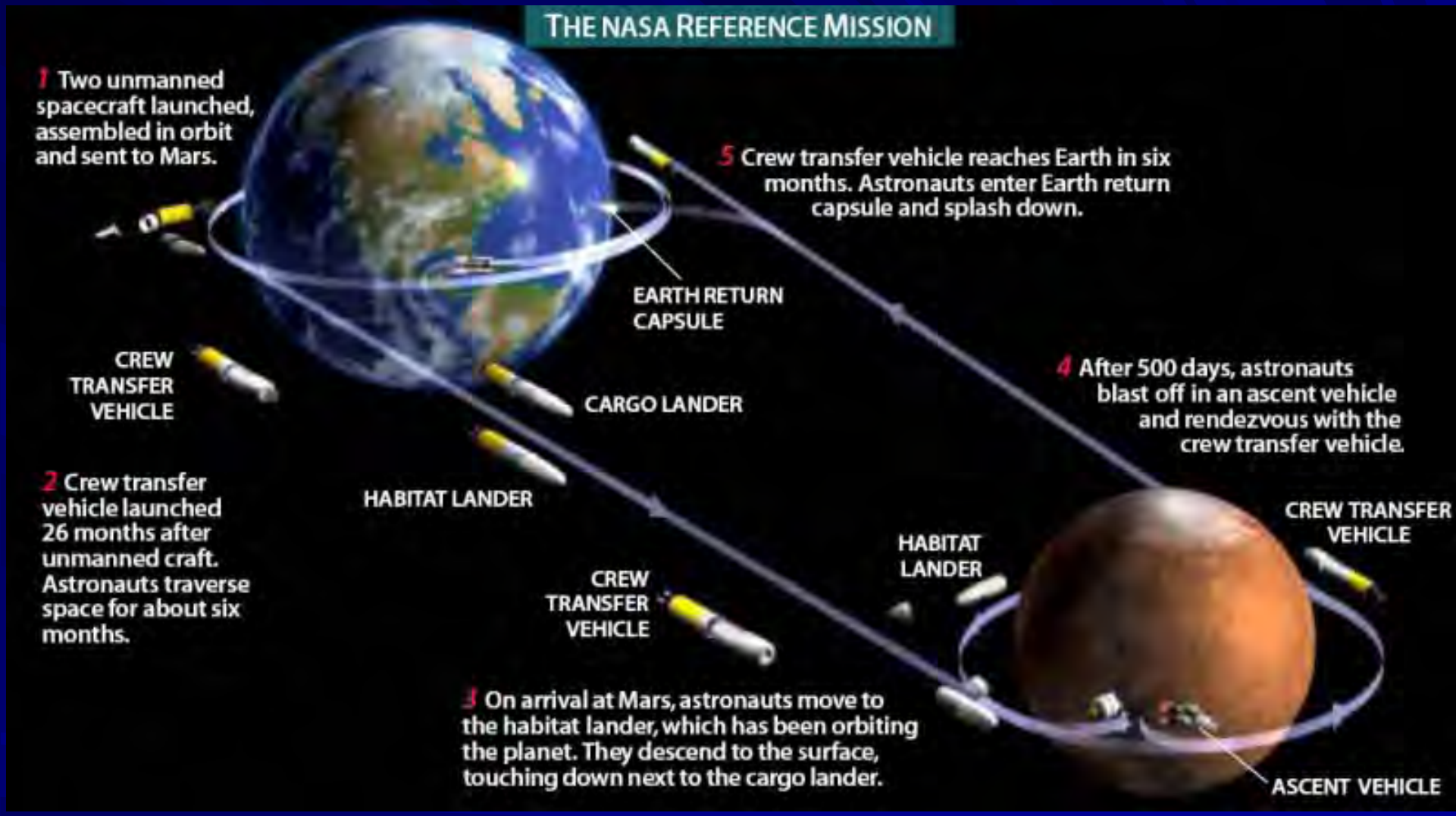


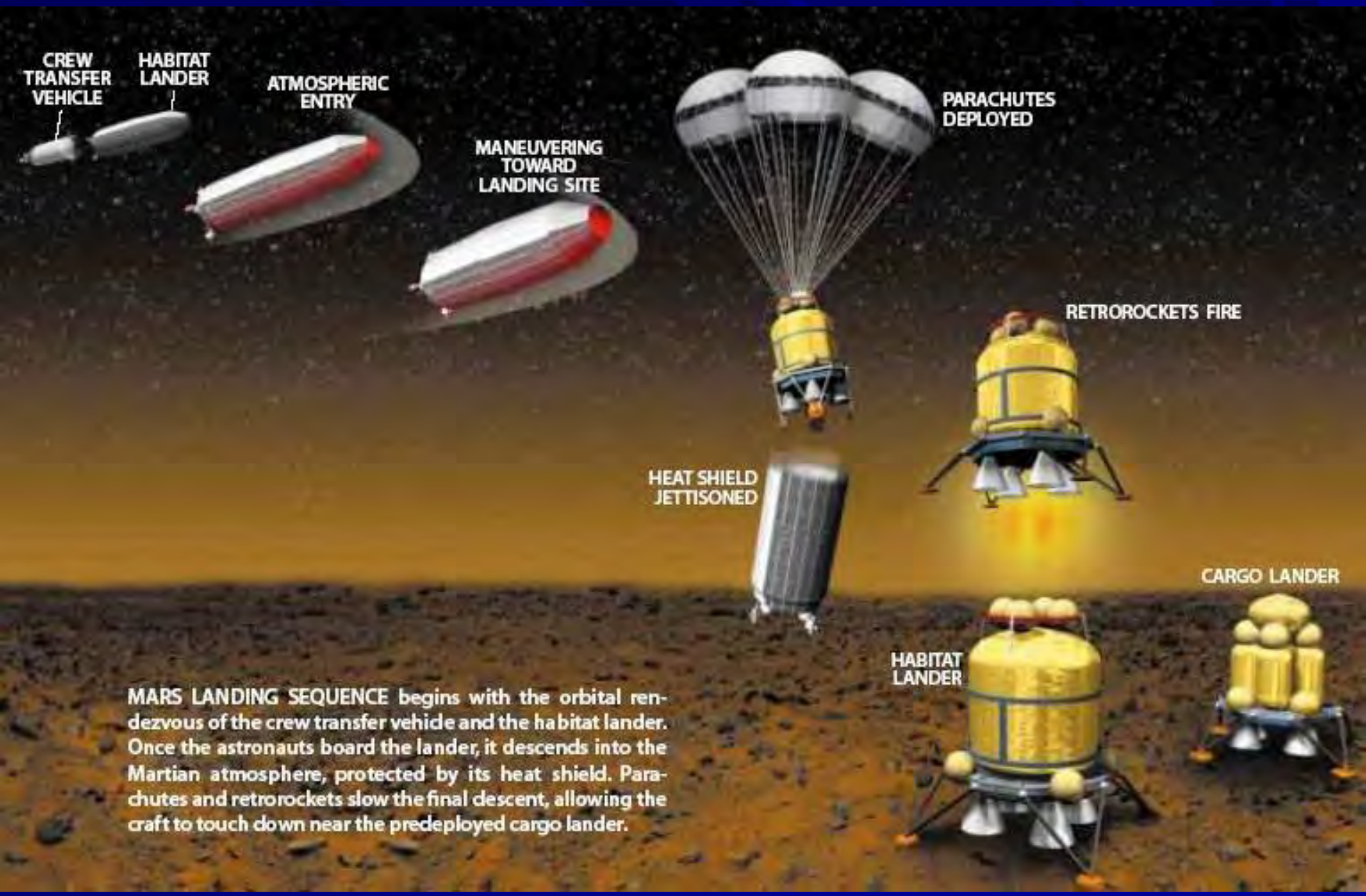
Processus type de stérilisation d’un échantillon de Mars

1. « Autonettoyage » substances chim./alcool
2. Four 120°C pendant 30 heures
3. Irradiation aux UV

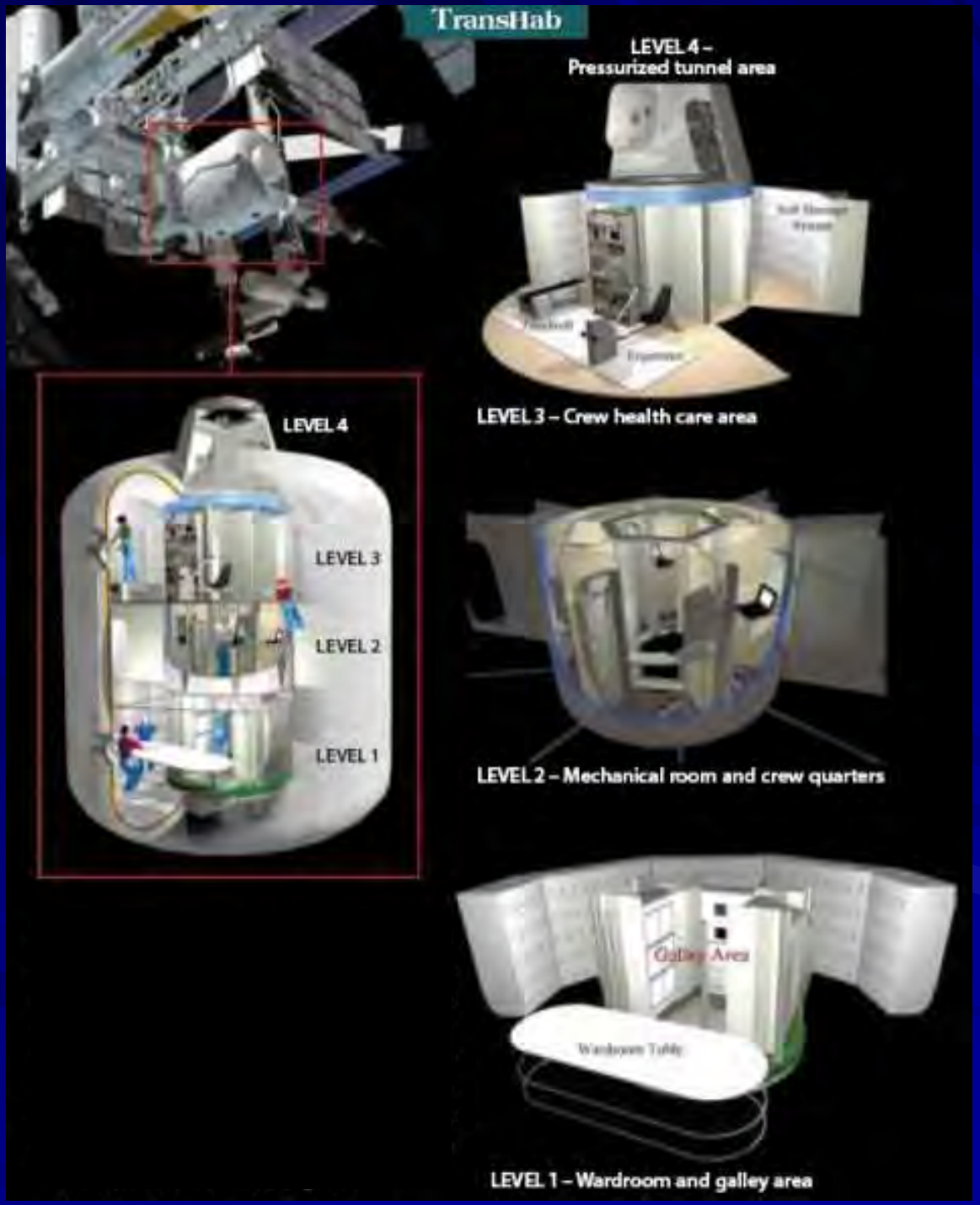
Charge utile (tonnes) à placer en orbite basse




THE NASA REFERENCE MISSION
1 Two unmanned spacecraft launched, assembled in orbit and sent to Mars.
5 Crew transfer vehicle reaches Earth in six months. Astronauts enter Earth return capsule and splash down.
EARTH RETURN CAPSULE
CREW TRANSFER VEHICLE
CARGO LANDER
4 After 500 days, astronauts blast off in an ascent vehicle and rendezvous with the crew transfer vehicle.
2 Crew transfer vehicle launched 26 months after unmanned craft. Astronauts traverse space for about six months.
HABITAT LANDER
CREW TRANSFER VEHICLE
HABITAT 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.
ASCENT VEHICLE



$$2\,CO_2 + 6\,H_2 \longrightarrow 2\,CH_4 + 2H_2O + O_2$$


TransHab
LEVEL 4 –
Pressurized tunnel area
LEVEL 3 – Crew health care area
LEVEL 4
LEVEL 3
LEVEL 2
LEVEL 1
LEVEL 2 – Mechanical room and crew quarters
Galley Area
LEVEL 1 – Wardroom and galley area


6

Coucher de soleil sur Mars

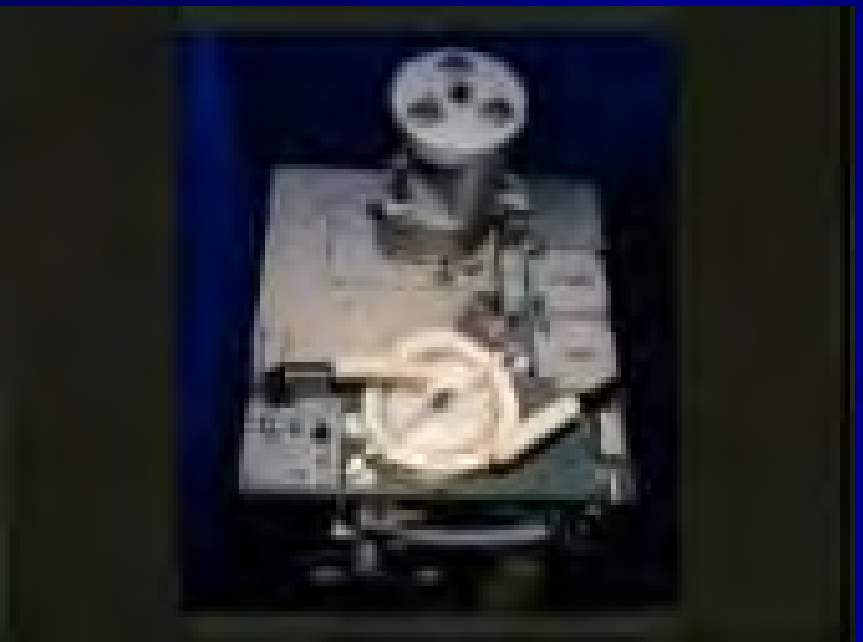
Avalanche de neige et de rochers sur Mars

Mars Science Laboratory, NASA

Départ: automne 2009, arrivée: octobre 2010

3. Soins hygiéniques et médicaux


КОЛПАЧКИ



Ozonisateur

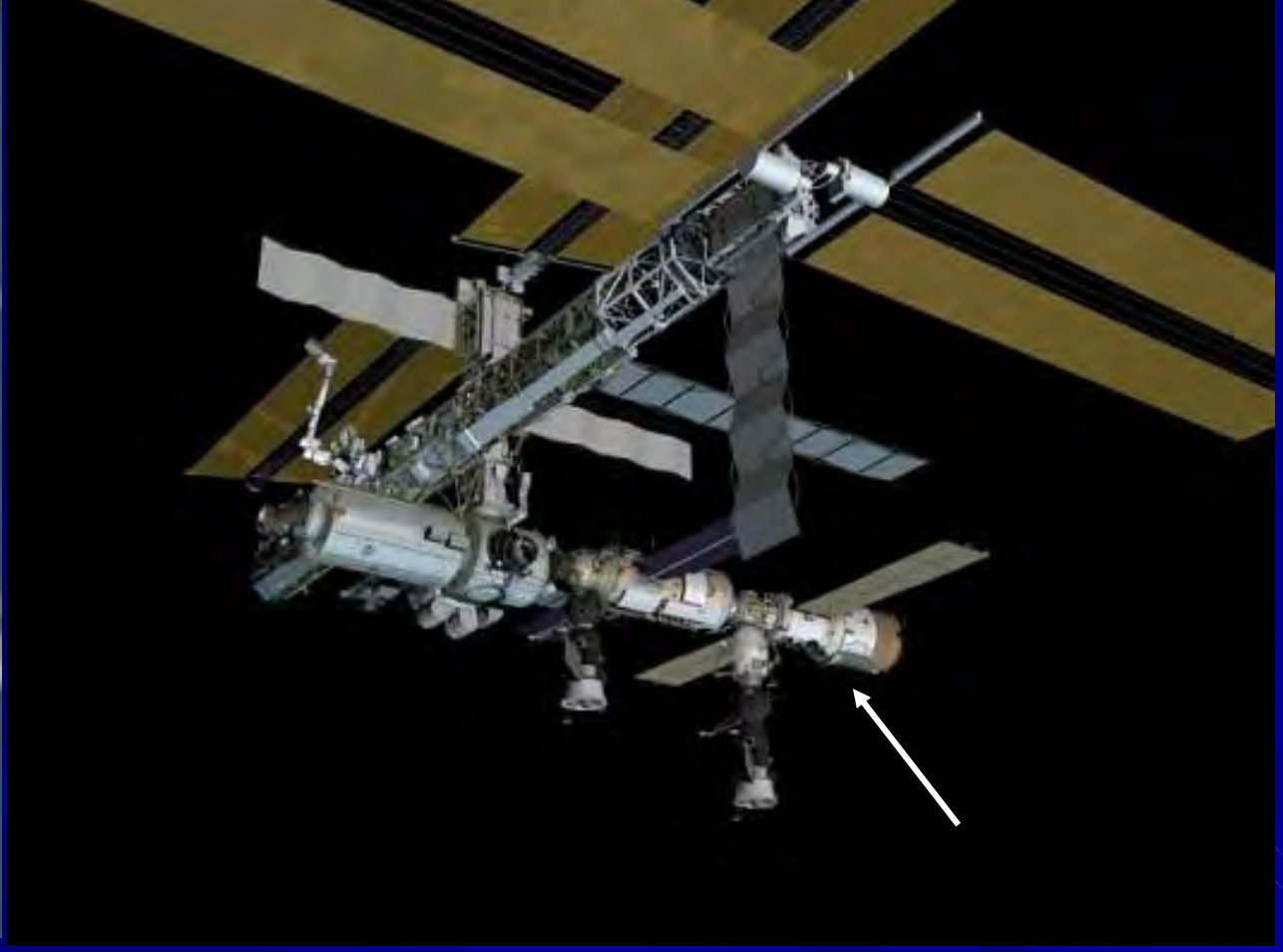
Boîte à gants stérile

Surgery and Recovery in Space

Authors

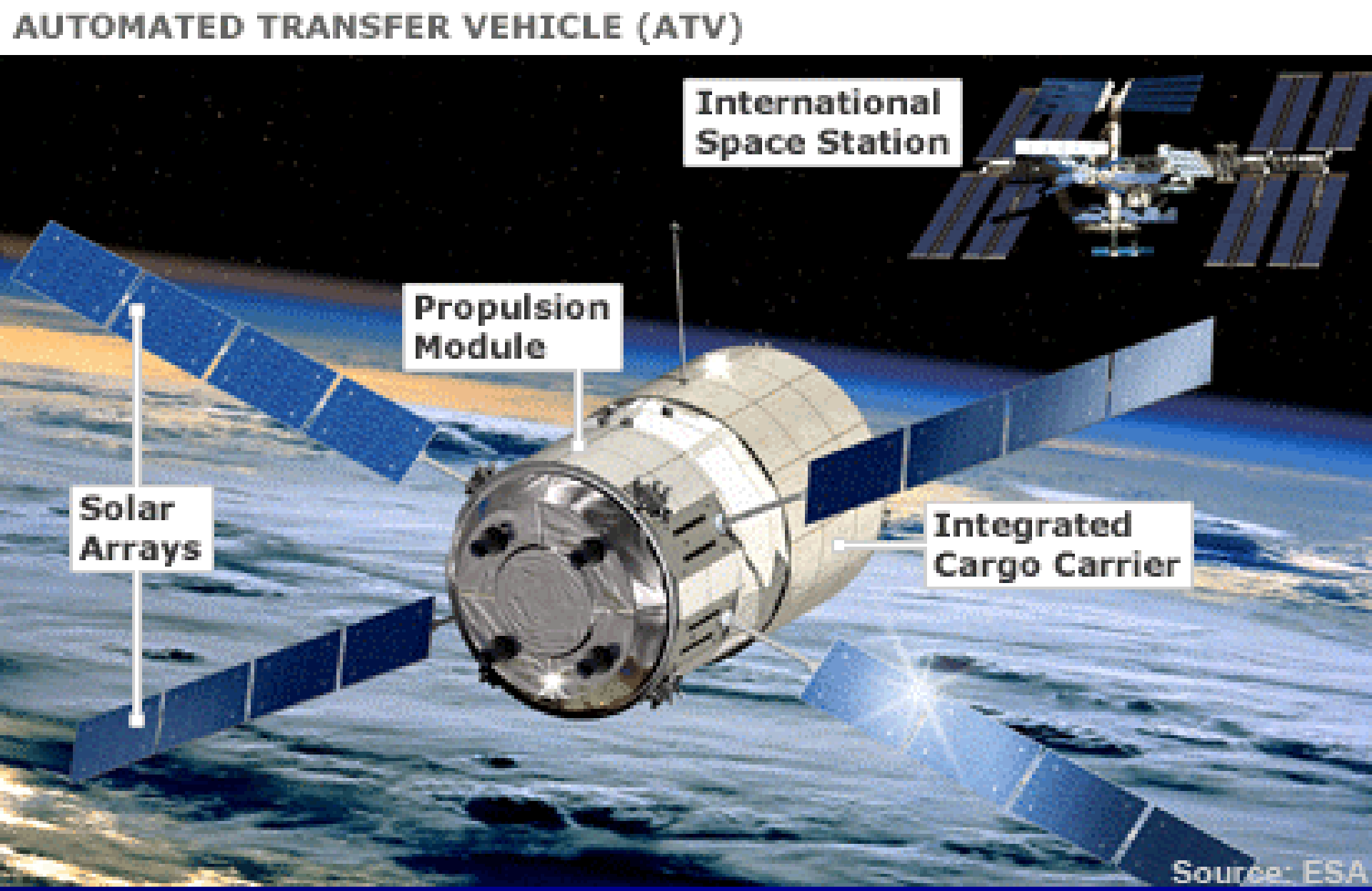
Jay C. Buckey, Jr., Dafydd R. Williams, Danny A. Riley

4. Recyclage des déchets



***Progress*, le vaisseau cargo russe**

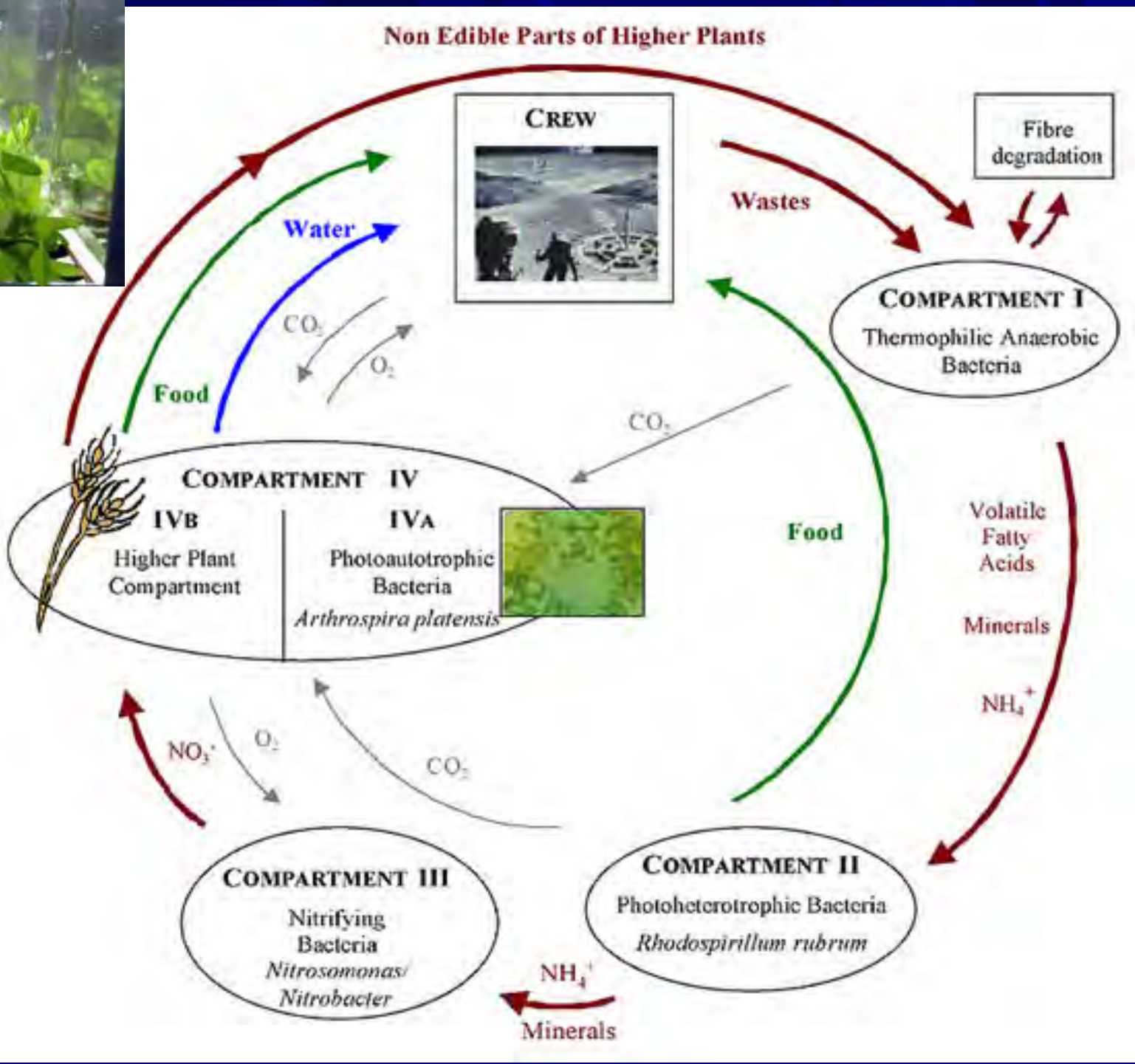
(ravitaillement et élimination des déchets)

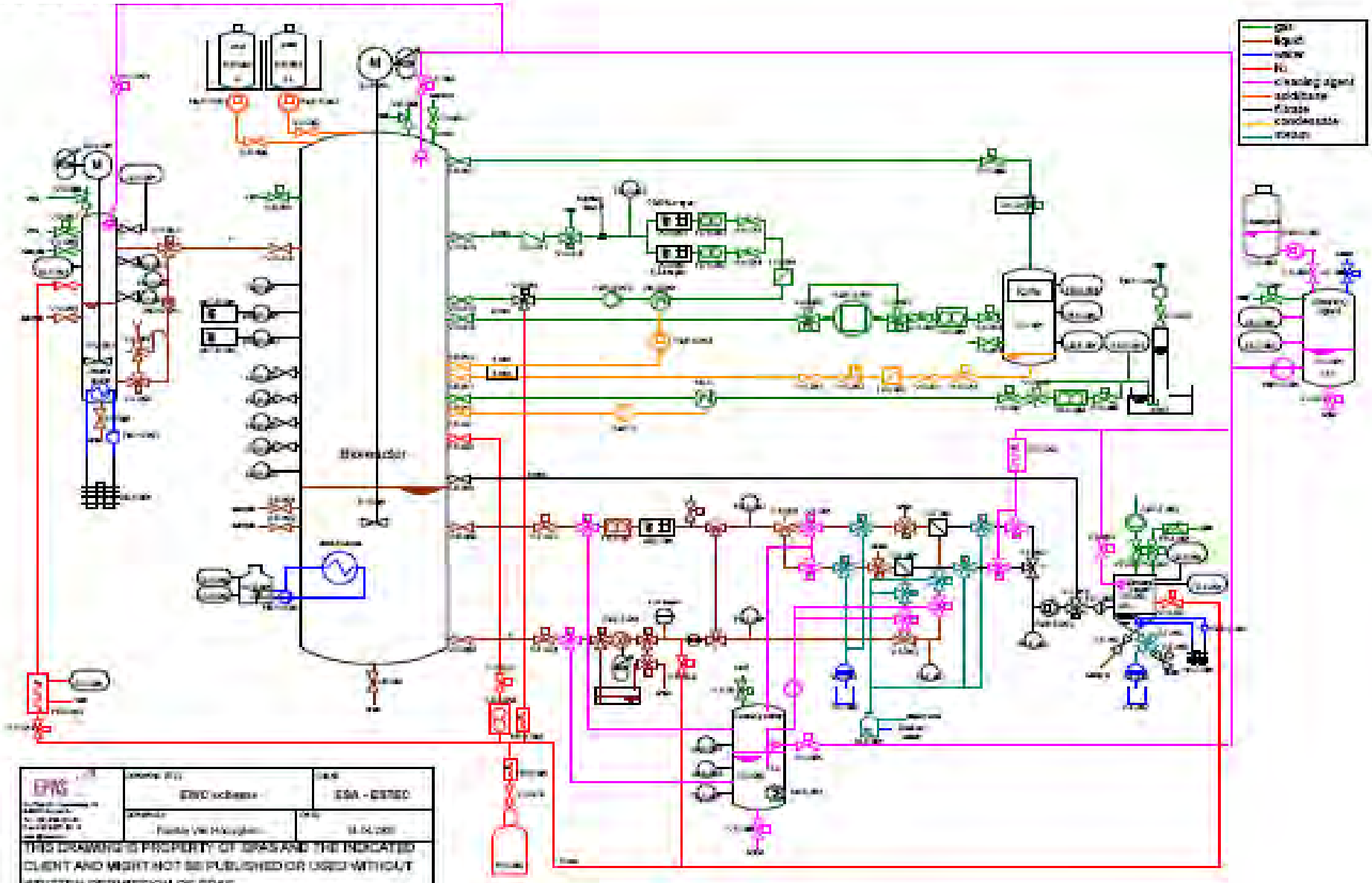


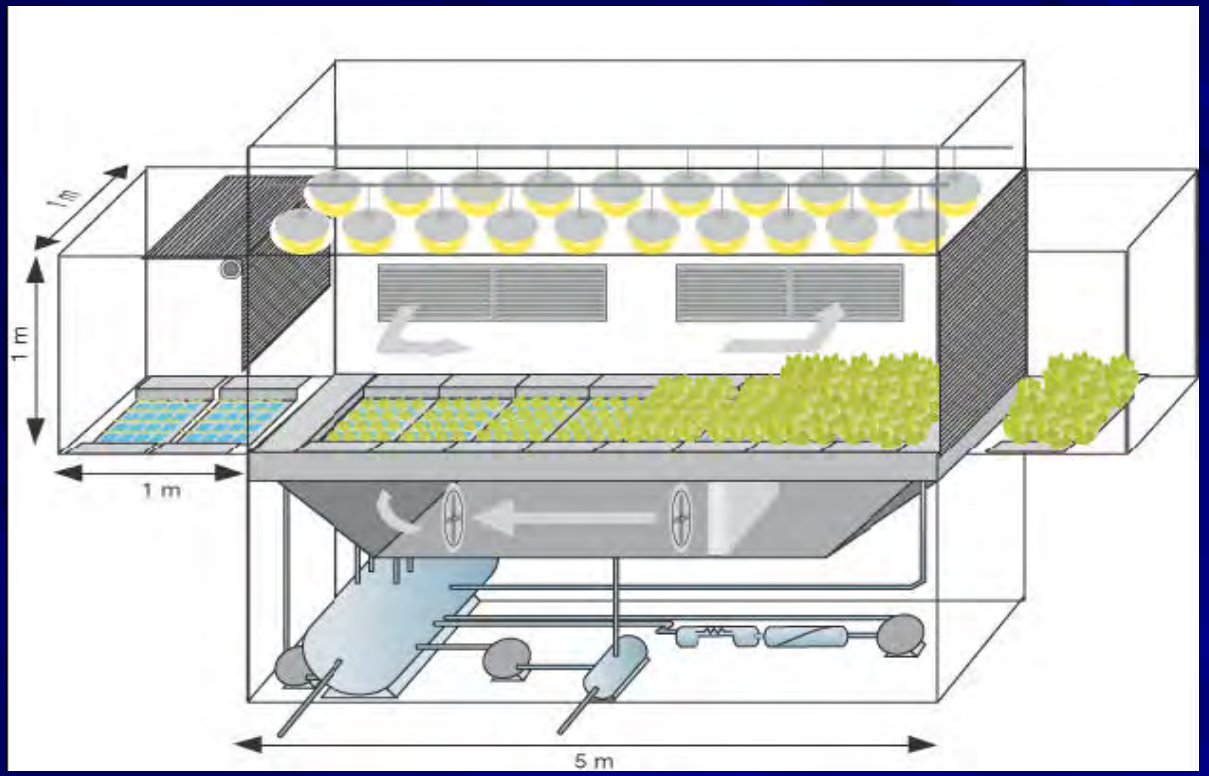
***ATV* (véhicule automatique de transfert), le vaisseau cargo européen**

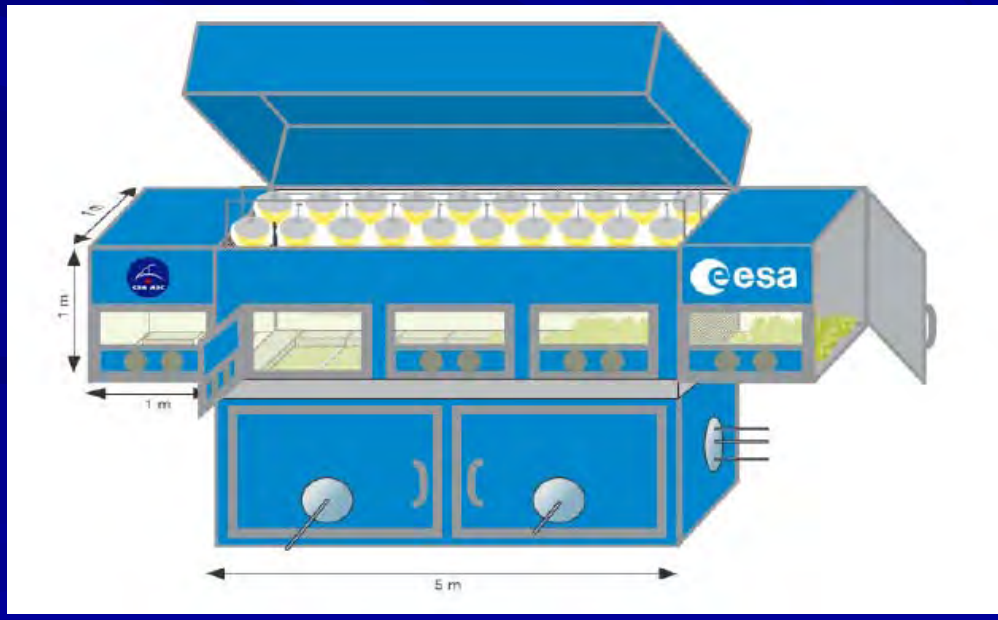
Concept MELISSA

Micro-Ecological Life Support System Alternative




Bioreactor
ESA - ESTEC
THIS DRAWING IS PROPERTY OF EPAS AND THE INDICATED
CLIENT AND MIGHT NOT BE PUBLISHED OR USED WITHOUT


1 m
1 m
1 m
5 m

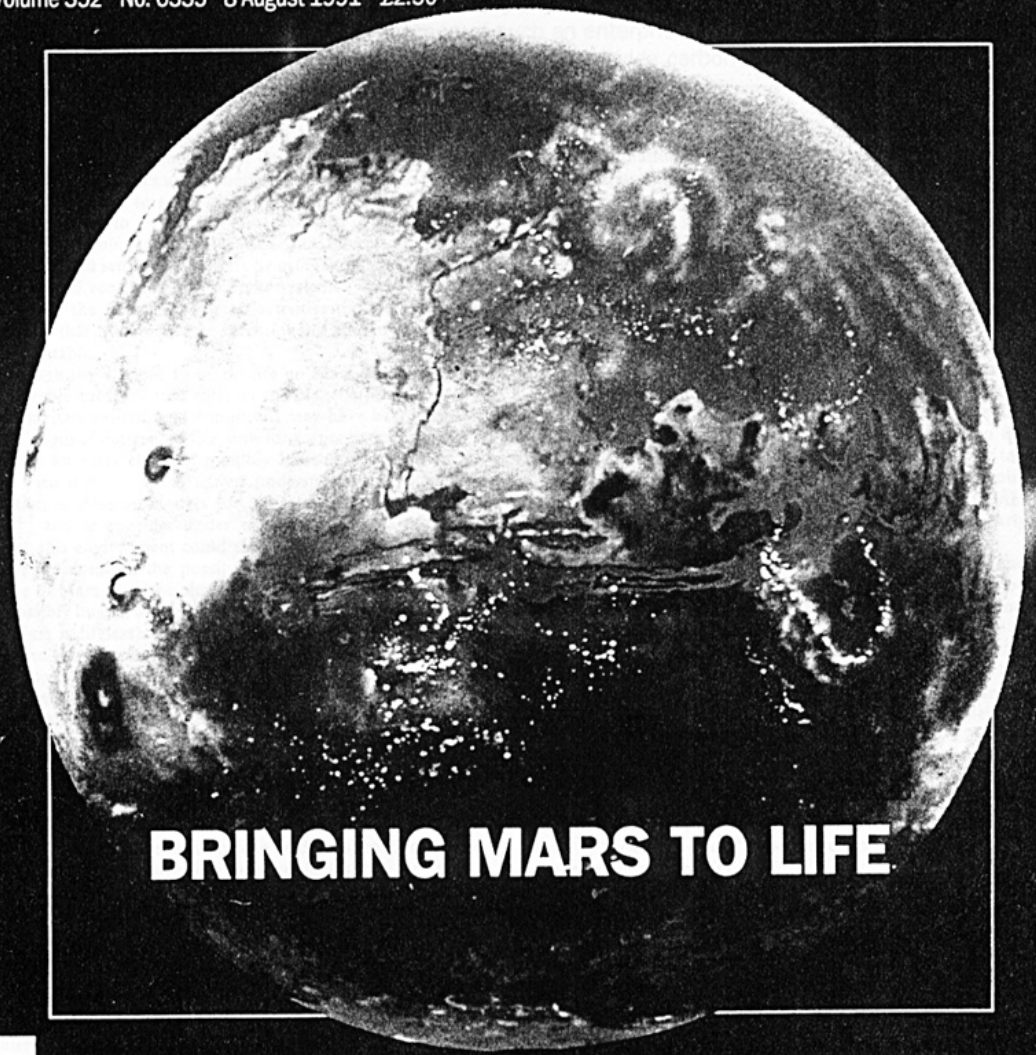

1 m
1 m
1 m
esa
5 m

5. Perspectives

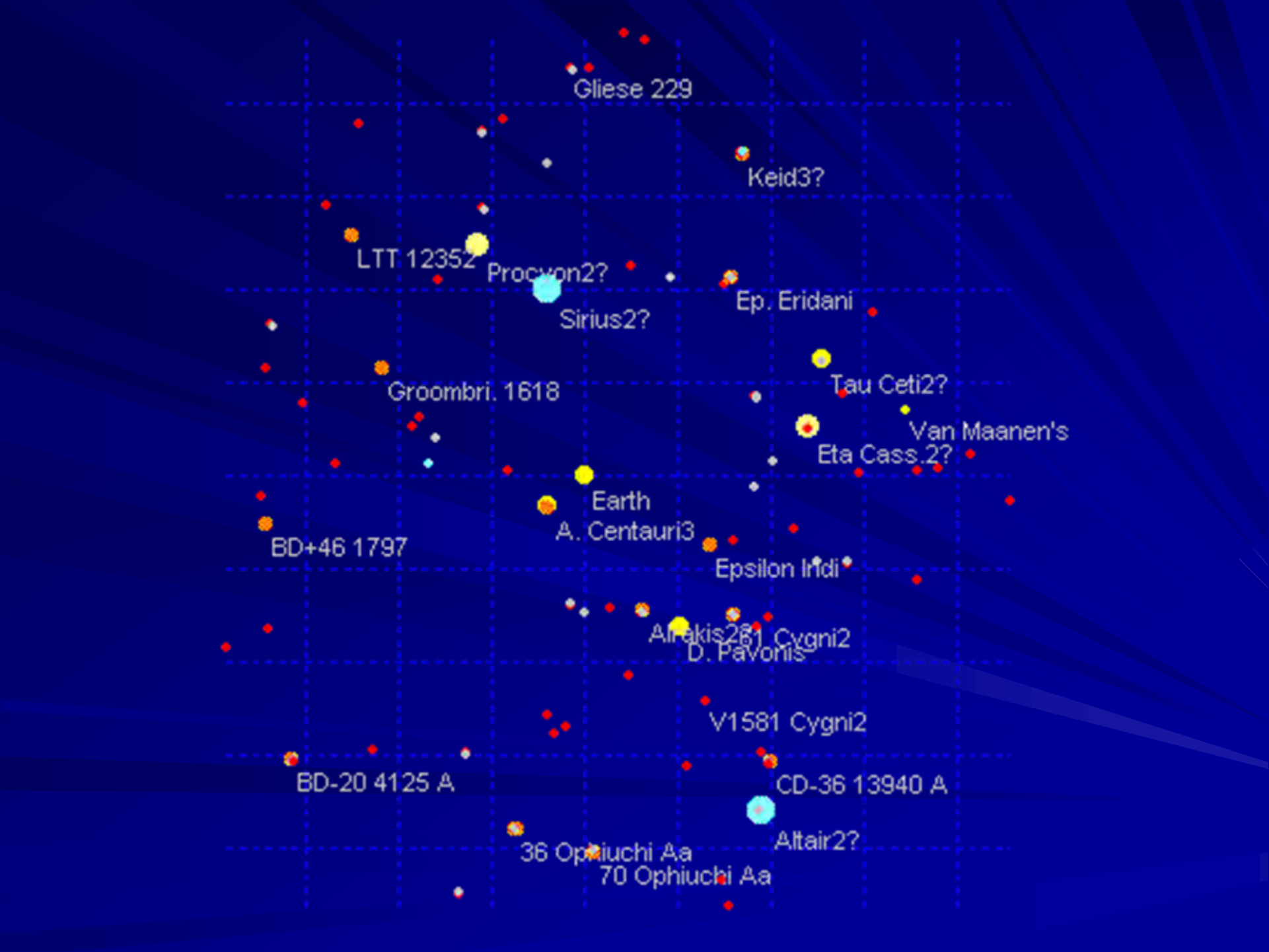
nature

INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

Volume 352 No. 6335 8 August 1991 £2.50

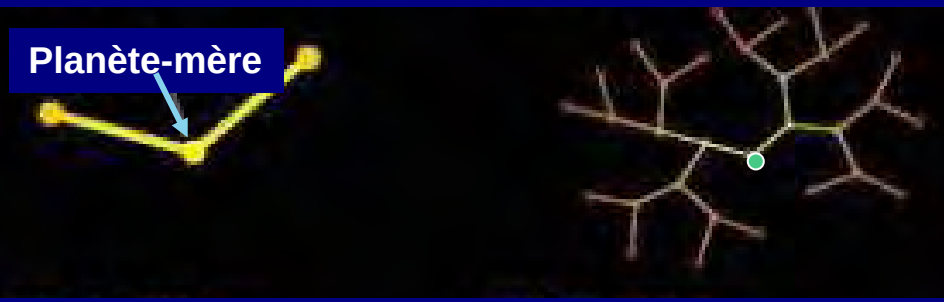


BRINGING MARS TO LIFE


Gliese 229
Keid3?
LTT 12352
Procyon2?
Sirius2?
Ep. Eridani
Groombri. 1618
Tau Ceti2?
Van Maanen's
Eta Cass.2?
Earth
A. Centauri3
BD+46 1797
Epsilon Indi
Arrakis261 Cygni2
D. Pavonis
V1581 Cygni2
BD-20 4125 A
CD-36 13940 A
Altair2?
36 Ophiuchi Aa
70 Ophiuchi Aa

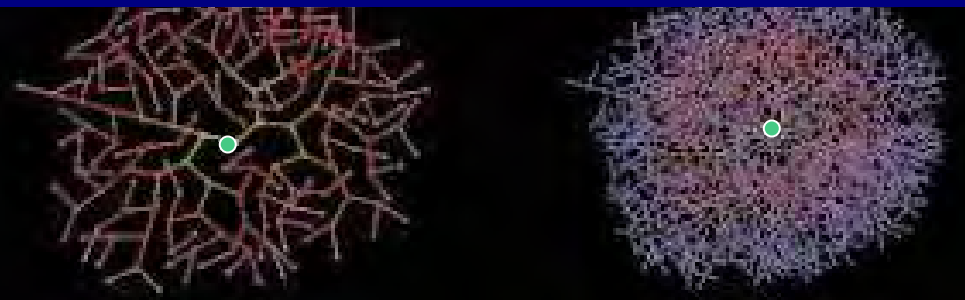
Après 1500 ans

Après 2000 ans

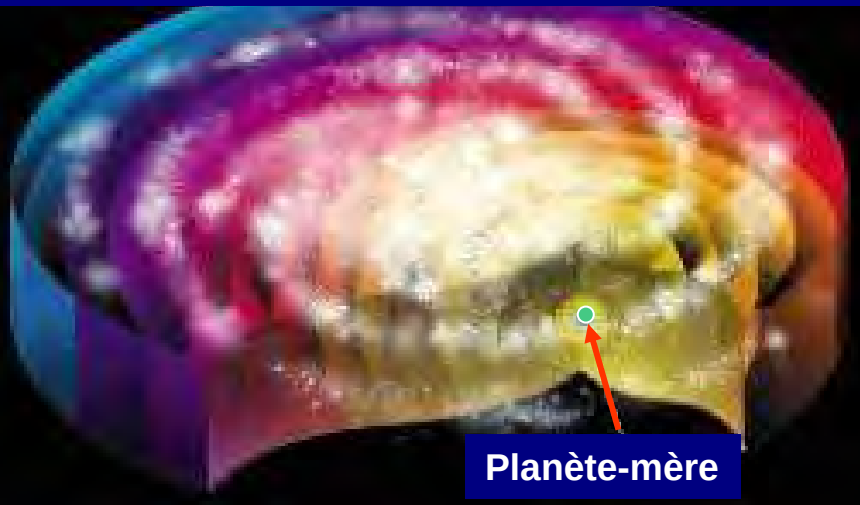


Après 3500 ans

Après 5000 ans



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



Tiré de:

J. Crawford

Sci. Am., juillet 2000

Merci de votre attention!