

## Molecules, Cells and Man: Science and Technology for the 'Moon Base' Project (MCM)

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Dipartimento di Patologia e Medicina Sperimentale e Clinica, Università degli Studi di Udine.



The “Moon Base” project:

a scientific view

*The first step towards the export of Earth life and Humankind to Space*

➤ **First priority: the preliminary assessment of Moon environmental risks**

➤ **The “MoMa” Scientific/Industrial community can help**

➤ **MoMa (“From Molecules to Man: Space Research Applied to the Improvement of the Quality of Life of the Ageing Population”):  
An Italian ‘ASI’ project in the field of ‘Medicine & Biotechnology’**

➤ **When and How?**

➤ **What is MoMa, and how it works?**

*The Origins*  
of the 'MoMa' Project

From 6 'old' Research Lines in the A.S.I.  
'Medicine & Biotechnology' area

To 3 'new' Lines:

**Radiobiology and Protection**  
**Cellular & Molecular Biotechnologies**

**Biotechnological Applications**

From the 6-Months  
'MoMa'  
Preliminary Study  
(2004)

To the 3-Years Applicative Project  
'MoMa'  
Just started (16<sup>th</sup> June, 2006)

REMODULING has been extensive  
For efficiency and effectiveness

MoMa 6-months Preliminary Study: the initial status (Jan. 2004)  
71 research groups, averaging 3-4 individual labs each



During the 6 months of the MoMa Preliminary Study:  
11 coordinated Groups identified in 4 Areas



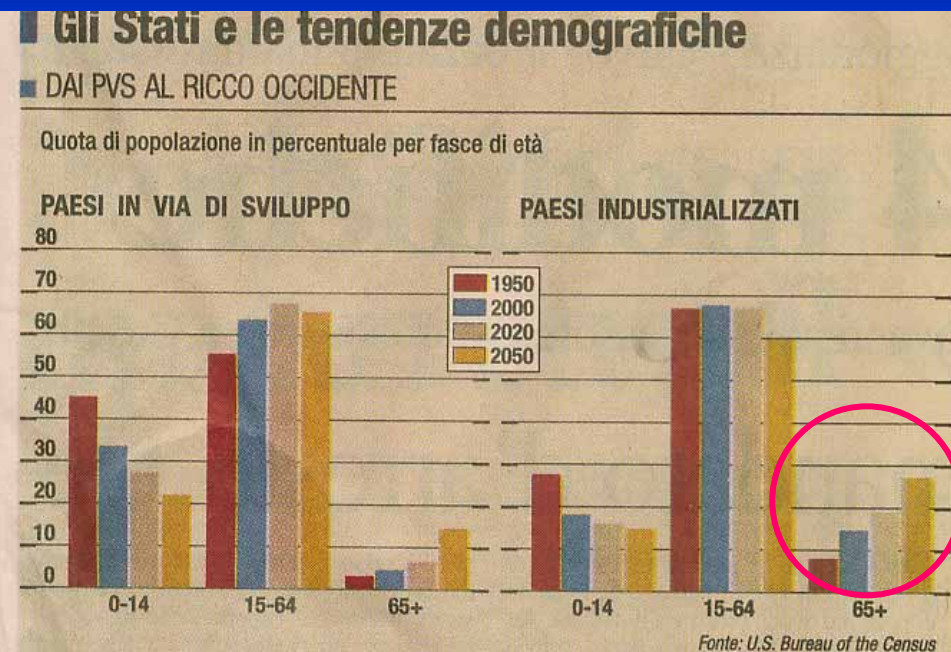
MoMa 3-years project  
2006 to 2009

MoMa: One Project, strongly focused towards 1 unifying Goal:

“AGEING and the QoL”: A strong, primary goal, particularly in Italy:

- Italy has the highest Life Expectancy: 80y (women: 83, man: 77)
- Italy has the lowest Fertility Rate: 1,27 (“Zero Growth” = 2,01)
- “Demographic implosion” ready to fire (i.e.: n° retired/working force) due to increasing ageing-related pathologies (i.e.: Tumors, Cardiovascular and Neurological Diseases, etc.)

MoMa:  
relevant ‘Fallout’ from  
Space research,  
particularly relevant in  
Industrialized Countries,  
especially in Italy



## SPACE relevancy of the MoMa topic: “AGEING and QoL”

- Space is a challenging, extreme environment ( $\mu$ g, space Radiation, ...)
- Lack of natural defences, no Darwinian Selective Pressure
- Cascade of molecular and cellular damages similar to Ageing
- The phenomenon of Accelerated Ageing in Space has been described
- Space Biotechnological Applications: very likely
- On-earth Biotech Applications fallout: very likely

**OVERALL GOAL**  
**of MoMa**

**TO STUDY**

**the accelerated ageing phenomenon in Space**

**THUS CONTRIBUTING**

**to the development of Biotec Applications, necessary for  
a safe exploitation and colonization of the Solar System  
and beyond**

**AND PURSUING**

**relevant fallouts on Earth, by developing  
Countermeasures against Ageing, thus significantly  
increasing the QoL of the Eldery**

## STRONG POINTS OF THE MoMa PROJECT

<u>Subject</u>	<u>Criteria for Excellency</u>
<b>Number of collaborating Staff</b>	<b>Over 500 groups of Scientists (50% women)</b>
<b>Number of collaborating Institutions</b>	<ul style="list-style-type: none"> <li>■ <b>38 (nationwide, in Italy)</b></li> </ul>
<b>Collaborating Industries and SME</b>	<b>9 (all major Space-related Italian Industries/SME)</b>
<b>Research / Ph.D. Fellowships</b>	<b>Over 250 (with Equal Opportunities)</b>
<b>Co-Financing (as Personnel time devoted to MoMa)</b>	<b>€17.182.211,40 (48% of the entire Project)</b>
<b>Total contribution to Industries/SME</b>	<b>€6.490.000 (36% the total budged requested to ASI)</b>



## MoMa EXPECTED PRODUCTS

➤ **Patents**

➤ **Biosensors**

➤ **Radioprotective Molecules and innovative Materials**

➤ **Recombinant proteins**

➤ **Innovative Enzymes**

➤ **Molecular Data Bases (sequences, structures, genes)**

➤ **Experimental proposals, approved by International Space Agencies**

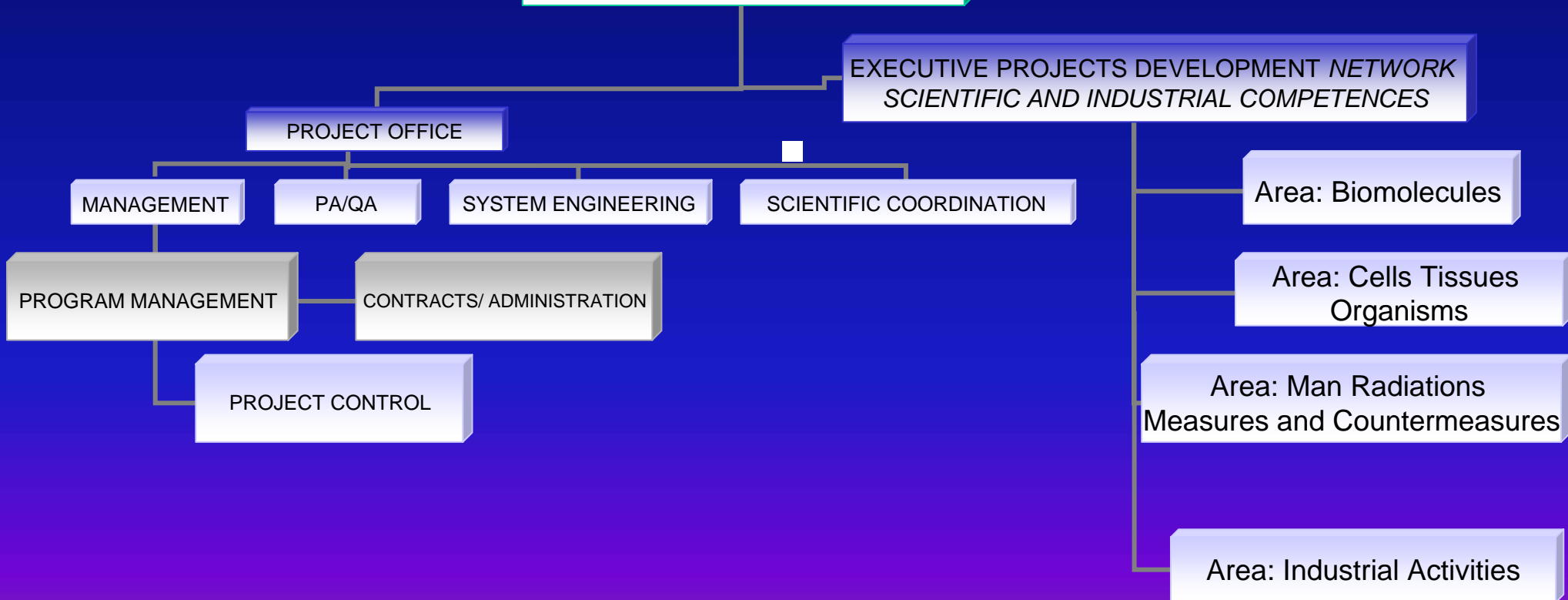
➤ **Publications in International Journals**

➤ **Development of Hardware for “Space” Biotec applications**

➤ **Development of Hardware for “Ground” Biotec applications**

# The MoMa Project

## General Outline



# SUBCONTRACTORS (Coordinators) (1/2)

## *Sciences:*

### **BONASSI Stefano**

Dipartimento di Eziologia ed Epidemiologia/TCE, INRC/ISS, Genova/Roma

### **CURCIO Francesco**

Dipartimento di Patologia e Medicina Sperimentale e Clinica, Università degli Studi di Udine.

### **DI MAURO Ernesto**

Dipartimento di Genetica e Biologia Molecolare, Università La Sapienza, Roma  
e Istituto di Biologia e Patologia Molecolari, CNR, Sezione Acidi Nucleici, Roma

### **DURANTE Marco**

Dipartimento di Scienze Fisiche dell'Università di Napoli "Federico II".

### **GIARDI Maria Teresa**

Istituto di Cristallografia, CNR, sezione di Montelibretti, via Salaria km 29,3 (Roma).

### **NARICI Livio**

Università di Roma 'Tor Vergata' – Dipartimento di Fisica & INFN – Sez Roma II

### **PALUMBO Giuseppe**

Dipartimento di Biologia e Patologia cellulare e Molecolare, Università di Napoli "Federico II"

### **PICCOLELLA Enza**

Dipartimento di Biologia Cellulare e dello Sviluppo dell'Università di Roma "La Sapienza"

### **RIZZO Angela Maria**

Istituto di Fisiologia Generale e Chimica Biologica "G. Esposito", Università degli Studi di Milano

### **ROSSI Mosè**

Istituto di Biochimica delle Proteine, CNR, Napoli.

## SUBCONTRACTORS (Coordinators) (2/2)

### *Industries / SME:*

**ADAMI** Giorgio

Alcatel Alenia Space Italia – Vimodrone MILANO (ex Laben)

# Organizational Chart of the Coordinated research lines

Area	Denomination	Acronym	Line	Acronym	Coordinator
I	BioMolecules	Mo	Prebiotic Chemical and Biochemical Processes	GSS&A	Di Mauro
			Hyperstable Molecular Tools	HTM	Rossi
II	Cells, Tissues, Organisms	Ce	Farmaci Anti Invecchiamento	FAI	Giardi
			Space Environment on Cellular Function: Developments and Applications	SE on CF	Curcio
			Animal Models to Study Deleterious Effects of Space.	ASSC	Rizzo
			New Biotechnologies to Evaluate Radiation and Microgravity Effects on Immune System.	ERMEIS	Piccolella
III	Man, Radiation, Countermeasures	Ma	Cosmic Radiation and Human Risk: Identification and Characterization of Specific Biomarkers.	XMAB	Palumbo
			Biodosimetry in Space: Validation of Novel Biomarkers of Chromosome Damage and Cancer Risk in Astronauts.	BCRI	Bonassi
			Anomalous Long Term Effects in Astronauts.	ALTEA	Narici
			Countermeasures for the Exposures to Galactic Cosmic Rays in Deep Space.	COUNT	Durante
IV	Industrial activities	In			Adami

# Area I: BioMolecules

## ➤ Limits of the present knowledge



**1. 1. Key Molecules in Ageing**

**1. 2. Modulating Molecules in Ageing**

**1. 3. Molecular and Cellular mechanisms in the Pathogenesis of Ageing**

## Area II: Cells, Tissues and Organisms

### ➤ Limits of the present knowledge

**2.1 Check points in the Aging process, cell transformation and death, also referring to differentiated cell systems and to the Immune system**

**2.2 Biological Models for the study of environmental factors capable of accelerating the Ageing process**

## Area III: Man, Radiation, Countermeasures

### ➤ Limits of the present knowledge

**3.1 Ratio between physical doses of radiation and long-term biological risks**

**3.2 Mechanisms of Central Nervous Tissue Ageing and its modulation from Environmental factors**

**3.3, 3.4 Lack of effective countermeasures to Space radiation effects**



## Area IV: Industrial activities

➤ **OVERCOME** the limits of our present technologies (just a few examples):

**4.1 Life Support System for RPM Clinostat**

**4.2 IMI: Italian MoMa Incubator**

**4.3 Biosensors**

**4.4 Altea - Altea 2 - Alteino**

**4.5 Bioreactor – Multiwell**

**4.6 External Bone Fixator**

# A synoptic view of the MoMa “Team”:

(Areas I-III: M–C–M)

## Area I Molecules

### **Ernesto DI MAURO**

Dipartimento di Genetica e Biologia Molecolare, Università di Roma “La Sapienza” e Istituto di Biologia e Patologia Molecolari, CNR, Sezione Acidi Nucleici, Roma

### **Mosè ROSSI**

Istituto di Biochimica delle Proteine, CNR, Napoli

## Area II Cells

### **Maria Teresa GIARDI**

Istituto di Cristallografia, CNR, sezione di Montelibretti, via Salaria km 29,3 (Roma)

### **Francesco CURCIO**

Dipartimento di Patologia e Medicina Sperimentale e Clinica, Università degli Studi di Udine

### **Angela Maria RIZZO**

Istituto di Fisiologia Generale e Chimica Biologica “ G. Esposito”, Università degli Studi di Milano

### **Enza PICCOLELLA**

Dipartimento di Biologia Cellulare e dello Sviluppo dell’Università di Roma “La Sapienza”

## Area III Man

### **Giuseppe PALUMBO**

Dipartimento di Biologia e Patologia cellulare e Molecolare, Università di Napoli “Federico II”

### **Stefano BONASSI**

Dipartimento di Eziologia ed Epidemiologia/TCE, INRC/ISS, Genova/Roma

### **Livio NARICI**

Università di Roma ‘Tor Vergata’ – Dipartimento di Fisica & INFN – Sez. Roma II

### **Marco DURANTE**

Dipartimento di Scienze Fisiche, Università di Napoli “Federico II”

Industrial  
Coordinator (In)

A.  
IV

### **Giorgio ADAMI**

Alcatel Alenia Space Italia - Laben

**Besides the Speaker (FSAI), the following MoMa participants are prepared to contribute to Moon Base:**

(Areas I-III: M - C - M)

Area I  
Molecules

**Ernesto DI MAURO**

Dipartimento di Genetica e Biologia Molecolare, Università di Roma “La Sapienza” e Istituto di Biologia e Patologia Molecolari, CNR, Sezione Acidi Nucleici, Roma

**Mosè ROSSI**

Istituto di Biochimica delle Proteine, CNR, Napoli

Area II  
Cells

**Francesco CURCIO**

Dipartimento di Patologia e Medicina Sperimentale e Clinica, Università degli Studi di Udine

Area III  
Man

**Marco DURANTE**

Dipartimento di Scienze Fisiche, Università di Napoli “Federico II”

Industries (In)

Area IV  
Industries

**Giorgio ADAMI**

Alcatel Alenia Space Italia - Laben

**Roberto AMENDOLA**

ENEA-BAS, Istituto per la Radioprotezione, Roma

# MoMa contribution to Moon Base (MCM #1, #2):

## Area I Molecules

### **#1. Prebiotic chemical and biochemical processes.**

**Ernesto DI MAURO**

Dipartimento di Genetica e Biologia Molecolare, Università di Roma "La Sapienza"  
e Istituto di Biologia e Patologia Molecolari, CNR, Sezione Acidi Nucleici, Roma

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### **#2. Hyperstable Molecular Tools.**

**Mosè ROSSI**

Istituto di Biochimica delle Proteine, CNR, Napoli

Themes of the AREA I. The Space environment as a tool for the study of Ageing: comprehension and prevention of molecular mechanisms.

- 1.1 Structural characterization of biomolecules relevant to Ageing;
- 1.2 Design of drugs relevant to degenerative pathologies;
- 1.3 Study of the mechanisms involved in DNA replication and repair;
- 1.4 Study of heath-resistant enzymes and their use in the production of molecules for Health and diagnostics.

# **MoMa contribution to Moon Base (MCM #3):**

## **Area II Cells**

### **# 3. Space Environment on Cellular Function: Development and Applications. Francesco CURCIO**

Dipartimento di Patologia e Medicina Sperimentale e Clinica, Università degli Studi di Udine

Themes of the AREA II. The Space environment as a tool for the study of Ageing: identification of cellular responses.

- 2.1 Critical mechanisms responsible for Ageing and Cell transformation;
- 2.2 Evaluation of environmental effects (microgravity, radiation) and study of the mechanisms in:
  - 2.2.1 Plants and microorganisms;
  - 2.2.2 Cellular systems derived from different organs and tissues;
  - 2.2.3 Animal models.

# **MoMa contribution to Moon Base (MCM #4):**

## **Area III Man**

### **#4. Countermeasures to the Exposure to Galactic Cosmic Rays in Deep Space. Marco DURANTE**

Dipartimento di Scienze Fisiche, Università di Napoli "Federico II"

Themes of the AREA III. The Space environment as a tool for the study of Ageing: development of countermeasures in Space and their fallout on Earth.

- 3.1 Biosensors and biodosimetry of ionizing radiation;
- 3.2 Neurodegenerative effects;
- 3.3 Physical countermeasures to radiation: development of new screening materials;
- 3.4 Medical countermeasures to radiation. Innovative molecules and food additives.

# MoMa contribution to Moon Base (MCM #5):

## Area IV Industries

Giorgio **ADAMI**

Alcatel Alenia Space Italia – (ex Laben)

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Roberto **AMENDOLA**

ENEA-BAS, Istituto per la Radioprotezione, Roma

This area will be described separately, hereafter

“From Molecules to Man: Space Research Applied to the Improvement of the Quality of Life of the Ageing Population (MoMa)”

CONCLUSIONS

The Proposers are confident that the MoMa Scientific and Industrial knowhow, facilities and technologies, may significantly contribute to the preventing and/or reducing the short- and long-term risks for the Biological Organisms and Humans exposed to the Lunar environment.

The PROPOSAL For Moon Base:

Molecules, Cells and Man: Science and Technology for the ‘Moon Base’ Project (MCM)  
- A long-term committment -



## Area IV: Industrial activities

### ➤ 4.1 Life Support System for Clinosat RPM

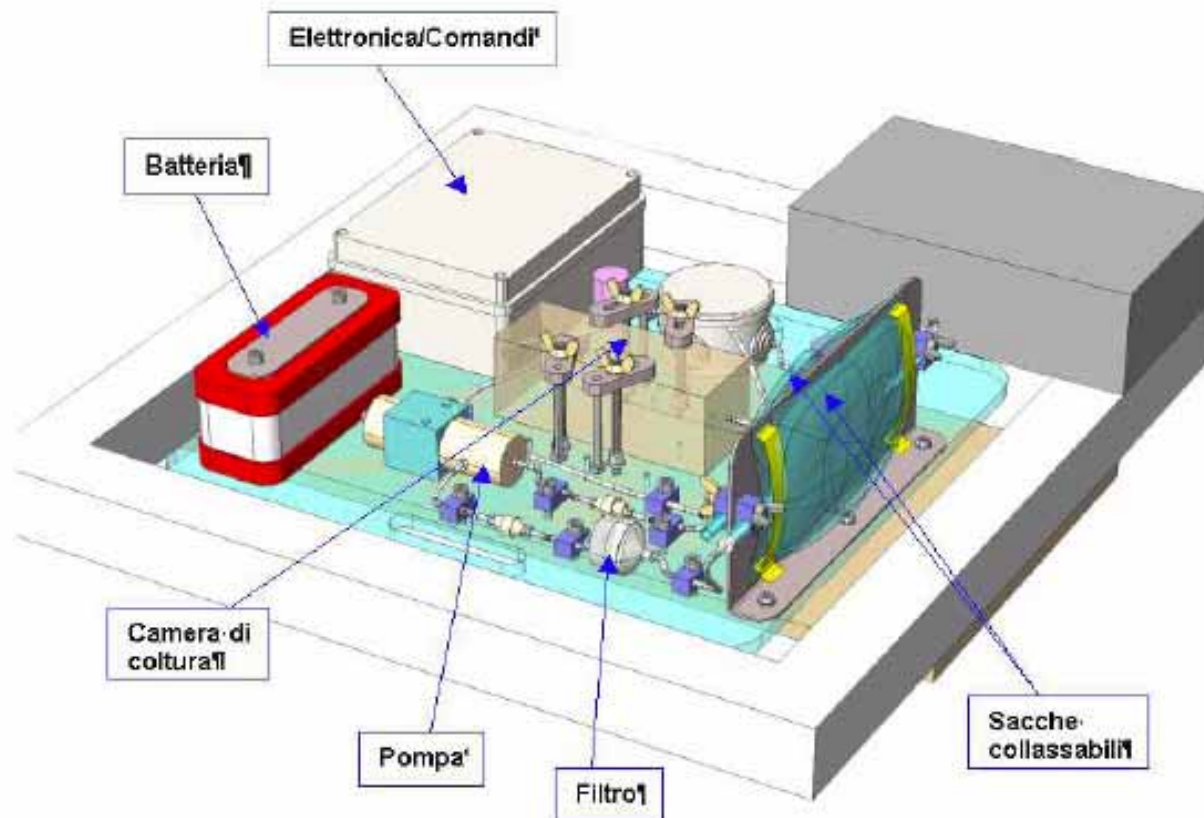
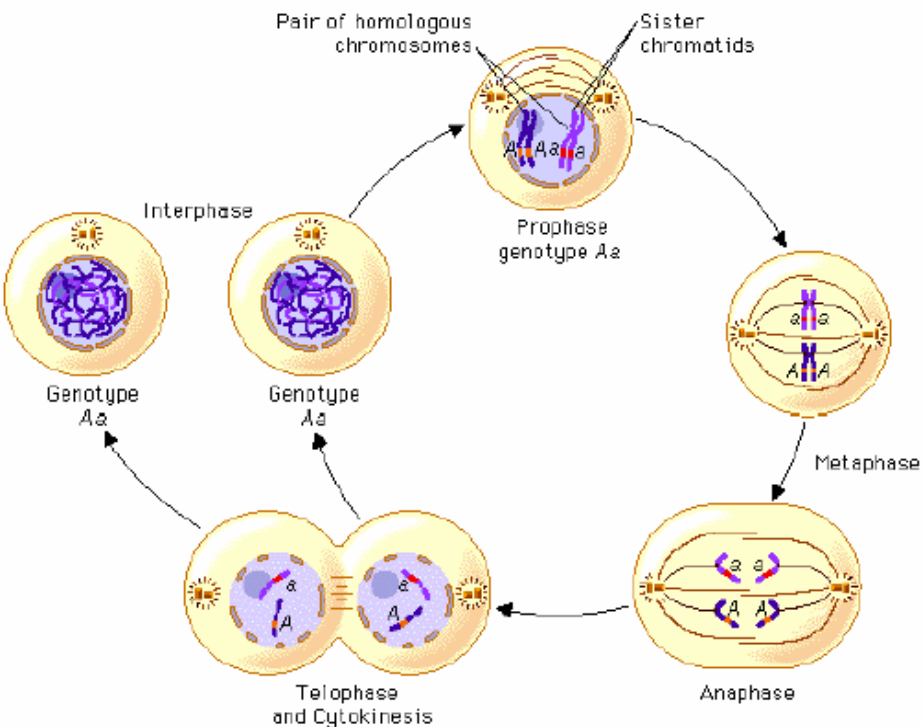


Fig. 6-1 Sistema montato su RPM



## Area IV: Industrial activities (introduction)

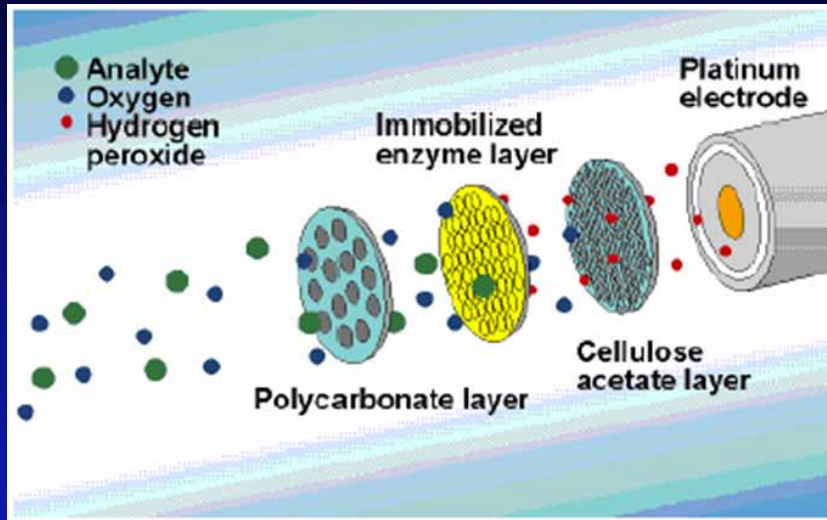
### ➤ IMI: Italian MoMa Incubator (facility)



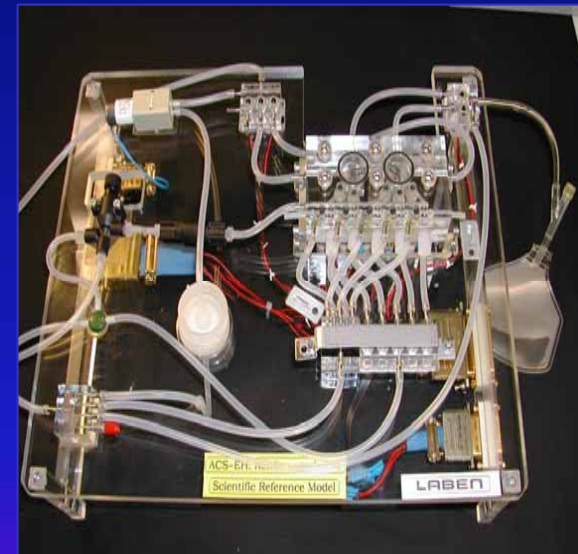
IMI integrated in the ISS Express Rack

# Area IV: Industrial activities (introduction)

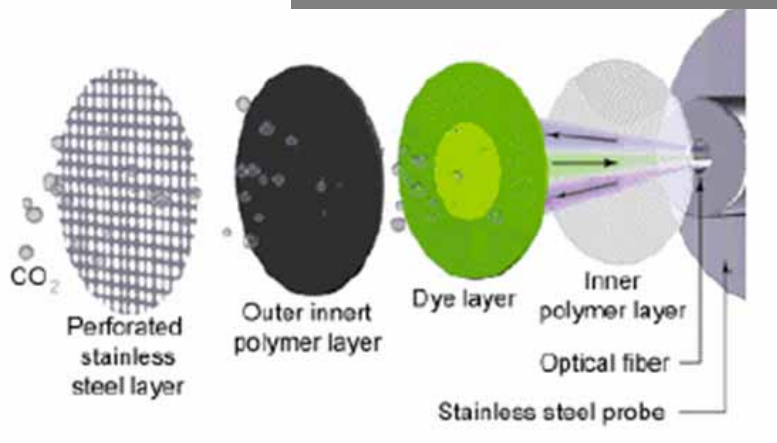
## ➤ Biosensors and devices (for experiments in Space)



Glucose monitoring sensor



Science reference model



CO2 monitoring sensor

# Area IV: Industrial activities

## ➤ 4.3 Biosensor

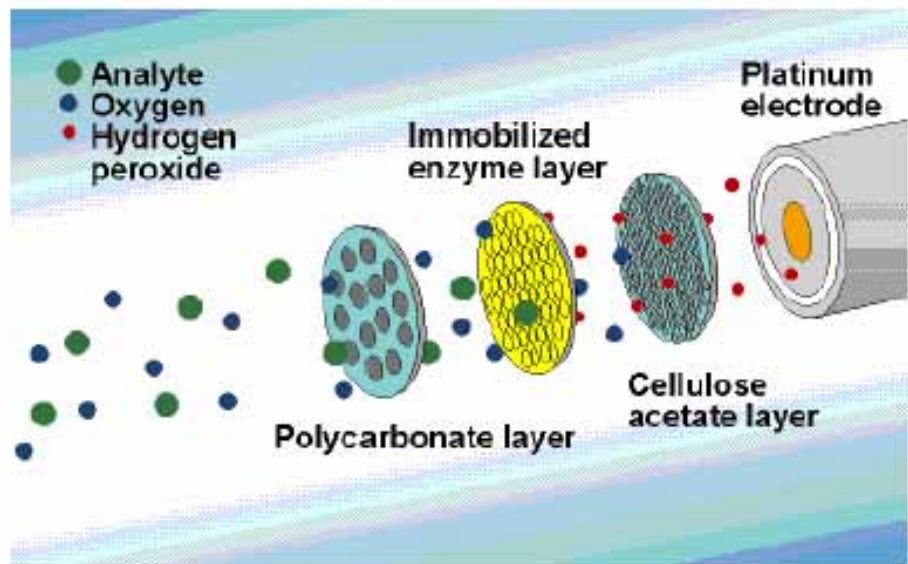


Figura 6.2.2.8-6 Struttura di un sensore di glucosio e lattato

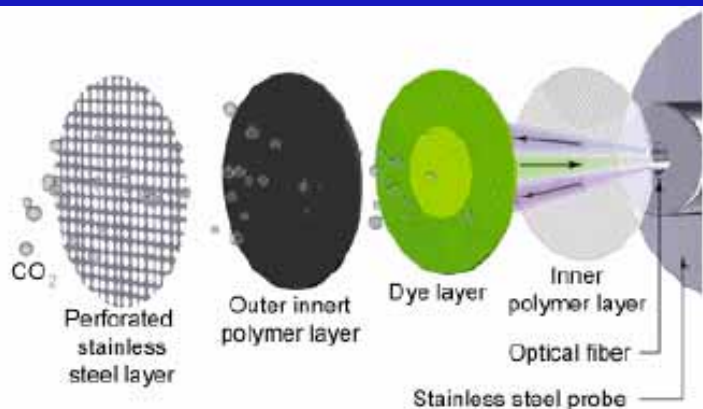


Figura 6.2.2.8-5 Struttura di un sensore di CO<sub>2</sub> disciolta

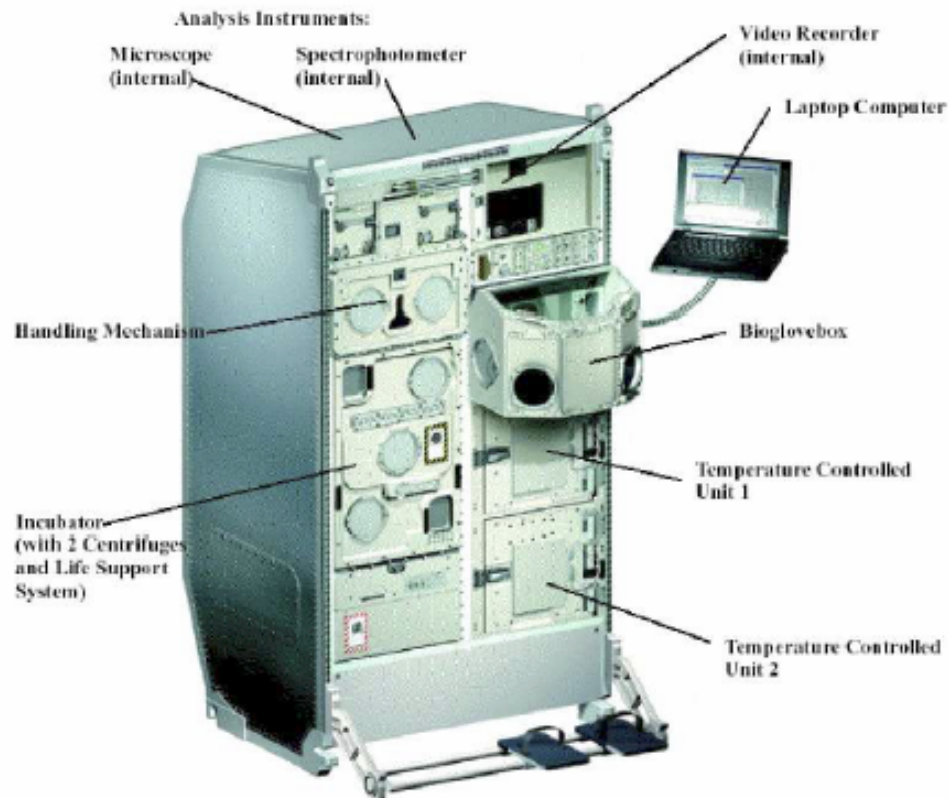


Figura 6.2.2.12-1 Immagine pittorica della facility europea Biolab

## Area IV: Industrial activities

### ➤ 4.4 Altea - Altea 2 - Alteino



## Area IV: Industrial activities

### ➤ 4.5 Bioreactor – Multiwell

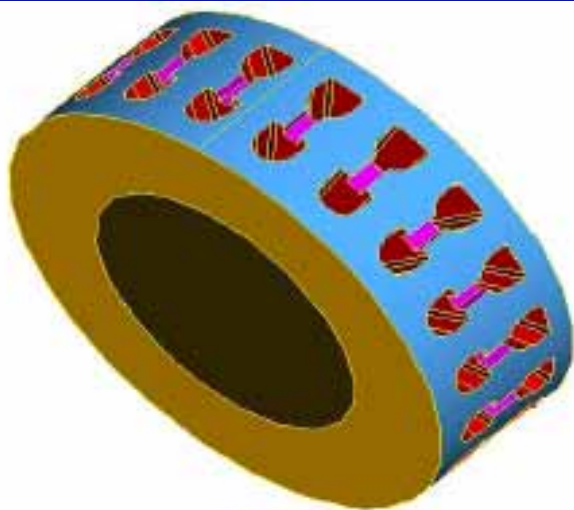


Fig. 6-10 Cilindro con 20 pozzetti da 200  $\mu$ l ognuno

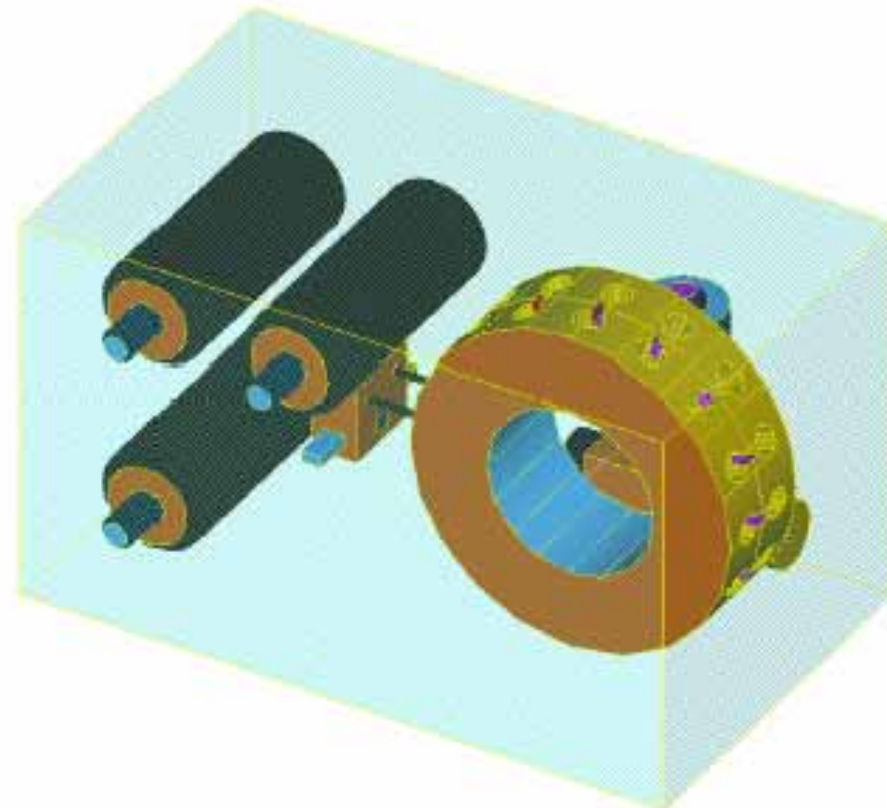


Fig. 6-11 Sezione di gestione dei liquidi