Space Biology Group (SBG) of the ETHZ at the Technopark Zurich Report 2001

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1. **PERSONNEL**

<table>
<thead>
<tr>
<th>NAME</th>
<th>FUNCTION</th>
<th>% OF EMPLOYMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanny Bellwald</td>
<td>Technician</td>
<td>100% 1st Jan.- 30th Sep.</td>
</tr>
<tr>
<td>Augusto Cogoli</td>
<td>Director of SBG</td>
<td>100%</td>
</tr>
<tr>
<td>Marianne Cogoli-Greuter</td>
<td>Scientific collaborator</td>
<td>75%</td>
</tr>
<tr>
<td>Nadine Conza</td>
<td>Scientific collaborator</td>
<td>80%</td>
</tr>
<tr>
<td>Amedeo Lamberti</td>
<td>Technician</td>
<td>100% 1st Nov.- 31st Dec.</td>
</tr>
<tr>
<td>Thomas Schopper</td>
<td>Technician</td>
<td>100%</td>
</tr>
<tr>
<td>Isabelle Walther</td>
<td>Scientific collaborator</td>
<td>100%</td>
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2. **SUMMARY OF CURRENT PROJECTS AND COLLABORATIONS**

2.1 Experiment *Leukin* to fly on Shuttle STS-107 in Summer-Fall 2002.

*Study of genetic expression of T cells in 0 g.*

In collaboration with University of California, S. Francisco, University of Sassari, Italy, ESA, ASI and NASA.

2.2 Experiment *Ystres* to fly on Shuttle STS-107 in Summer-Fall 2002.

*Study of osmotic and heat stress on Saccharomyces cerevisiae in a space bioreactor*

In collaboration with ESA, NASA, Seyonic (Neuchâtel) and Mecanex (Nyon).

2.3 Experiment *Lymphosig* to fly on sounding rocket MASER 9 in March 2002

*Study of expression of early genes in T cells in 0 g*

In collaboration with ESA, ASI, Fokker Space (Leiden), Swedish Space Corporation, University of Sassari, University of Rome.

2.4 Experiment *CODI* to fly on sounding rocket MASER 9 in March 2002

*Study of genetic expression and cytoskeleton structure of chondrocytes in microgravity*

In collaboration with ESA, Fokker Space, Swedish Space Corporation, Sulzer Medica, University of Münster.
2.5 Experiment Cell-Cell interactions to fly on TBD mission in 2003/2004

**Study of movements of monocytes and their interactions with T cells in 0 g**

In collaboration with ESA, ASI, University of Sassari, University of Rome.

2.6 Experiment Apoptosis to fly on TBD mission in 2003/2004

**Role of Programmed Cell Death (Apoptosis) in the Depression of Human T Lymphocyte Activation in Microgravity**

In collaboration with Universities of Rome and Sassari.

2.7 Project within the Microgravity Application Program of ESA

Study of tissue engineering applications on the International Space Station: cartilage and vascular tissue and thyroid cells

**Modular Space Bioreactor for medically relevant organ-like structures**

In collaboration with ESA, Sulzer Medica, University of Tübingen, University of Hamburg; University of Münster, University of Udine.

2.8 Project Gradient bioreactor

**Development of a gradient bioreactor for the International Space Station**

In collaboration with ESA, Mecanex, Seyonic, University of Udine, Istituto Dermopatico dell’Immacolata, Rome.

2.9 Project Spheroids

**Study of the effect of simulated microgravity on the differentiation and apoptosis in human follicular thyroid carcinoma cells**

In collaboration with Freie Universität Berlin, Max-Planck Institute of Biochemistry, Martinsried, University of Regensburg.

2.10 Project Osteoclasts

**Study of differentiation and function of osteoclast in simulated microgravity**

In collaboration with ASI and University of Florence.

2.11 Project cardiovascular tissue

**Growth and assembly of bovine aorta cells**

Study of morphology differentiation and aggregation of aorta smooth muscle cells in simulated microgravity.

In collaboration with Istituto Dermopatico dell’Immacolata, Rome

2.12 Project BIOTESC, Biotechnology Space Support Center

**User support and operation center**

In June 2002 the ETHZ and ESA have signed an agreement to establish on the premises of the Space Biology Group an Utilization, Support and operation Center to assist the users of the BIOLAB facility on the International Space Station.

In collaboration with ESA, DLR, Cologne.
3. COOPERATION AGREEMENTS

3.1 With ESA

3.1.1 Biopack
Biopack is a new facility for biological experiments in space developed by a Dutch and a Swiss company under contract to ESA.
Three experiments proposed by the SBG-ETHZ have been selected by ESA to fly in Biopack.
The development of the instrumentation for the experiments is funded by ESA within the frame of the PRODEX program (Program of Development of Experiments). Four contracts have been stipulated between the ETHZ and ESA, one concerning the development of Biopack, and three concerning the development of the instruments required by each of the three experiments.
The first flight of Biopack, with two of the three experiments is scheduled in July 2002.

3.1.2 Microgravity Application Program (MAP)
The ETHZ has signed in May 2000 a contract with ESA for the definition of the requirements of a modular space bioreactor for medically relevant organ-like structure. ESA is financing the project for two years with a sum of 640,000 Euro. This sum is shared with four other universities (Tübingen, Harburg-Hamburg, Münster and Udine) participating to the project. Sulzer Medica is investing an analogous sum as industrial partner.

3.1.3 ESA Center of Excellence for Biotechnology in Space, BIOTESC
The ETHZ has signed in June 2000 a 10-year contract with ESA for the establishment of a user center for the coordination of biological and biotechnological projects in the BIOLAB facility to be installed on the International Space Station. The ETHZ is providing office and lab facilities and 1/3 position, ESA is participating with 100,000 Euro/year.

3.2 With Agenzia Spaziale Italiana/University of Sassari
In 1989 a scientific collaboration on several space missions and ground-based investigations was established with the “Dipartimento di Scienze Fisiologiche, Biochimiche e Cellulari” of the University of Sassari. The activities of the SBG were supported in 2001 with ASI funds of approximately 40,000 Euro.

3.3 With NASA/University of California
Dr. Millie Hughes-Fulford of the University of California, S. Francisco, is a co-investigator on the Leukin experiment (s. 2.1). NASA is funding her activities in 1999-2001 with US$ 250,000.

3.4 With Fokker Space
With this company we are developing two instruments for the sounding rocket MASER 9 scheduled for launch in March 2002 (s. 2.3, 2.4). Such activity is funded by ESA with 58,000 CHF.

3.5 With Sulzer Medica, Winterthur
In the frame of the MAP project Sulzer is providing technical and scientific assistance and instrumental devices for the growth of cartilages in vitro.

3.6 With Mecanex S.A., Nyon

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1 MASER 9 was successfully launched on March 16th 2002.
Mecanex is the prime contractor with ESA for a study (phase A and B) on the development of a “gradient bioreactor system”. The SBG is a subcontractor with Mecanex for a sum of approx. Fr. 130’000.-.

4. PROJECTS

4.1 Project Biopack
The Swiss participation consists of three concomitant activities: Biopack "core elements", Biopack "experiment-specific instruments" and Biopack Experiments. The manufacture of the Biopack core elements and of the specific instruments was terminated in Summer 2001. The experiment sequence test (EST, a complete simulation of the in flight operations with all experiment specific instruments) was carried out in September at ESTEC. Some phases of the EST have to be repeated in March 2002 (see footnote p. 3). The SBG was involved in the development of the Biopack core elements as well as in the development and functional tests of the experiment specific instruments required by the three Swiss experiments.

4.1.1 The three Swiss Biopack Experiments
The three experiments are "Role of interleukin-2 receptor in signal transduction and grav-sensing threshold of T lymphocytes", principal investigator A. Cogoli; "Yeast cells: stress under microgravity”, principal investigator I. Walther; and "Cell-Cell interaction of monocytes and T lymphocytes in microgravity”, principal investigator M. Cogoli-Greuter. The first two will fly in Biopack in Shuttle flight STS-107 in July 2002; the third on a later mission. A. Cogoli is co-investigator of a fourth project selected for Biopack: “Role of Programmed Cell Death (Apoptosis) in the Depression of Human T Lymphocyte Activation in Microgravity” where M. Maccarrone of the University of Rome is the principal investigator.

4.2 Project MASER 9: Two Experiments
One experiment is dedicated to the study of genetic expression of early genes in T cells exposed to 0 g, the other is part of the MAP project and will investigate the genetic expression of matrix proteins and the histology of chondrocytes exposed for a few minutes to 0 g. Both experiments require experiments hardware that was developed in collaboration with Fokker Space.

4.3 Project MAP
The project Modular Space Bioreactor for medically relevant organ-like structures was started in May 2000 with the following partners:
Dr. Augusto Cogoli, ETH Zürich, team leader
Prof. Saverio Ambesi, UNI Udine, I, thyroid cells
Dr. Augustinus Bader, UNI Tübingen, D, vascular tissue
Prof. Peter Bruckner, UNI Münster, D, chondrocytes/cartilage
Dr. Peter Bittmann, Sulzer Medica, Winterthur, CH, chondrocytes/cartilage
Dr. Ralf Pörtner, UNI Hamburg, D, bioreactor technology
Dr. Isabelle Walther, ETH Zürich, space bioreactor technology.
The objectives and strategy of the project are summarized below.
The production of artificial tissues and organ-like structures is one of the most innovative and timely technologies. The understanding of the molecular and biological mechanisms regulating the growth and survival of such structures is a necessary prerequisite for medical applications. It is believed that microgravity may contribute in two aspects to progress in this field. First, as shown in other systems, microgravity is a useful tool to investigate important biological events at the cellular and molecular levels (e.g. signal transduction, genetic expression and cell proliferation) from a new and non-invasive (i.e. avoiding inhibitors or other biochemical agents) standpoint. Second, low-g conditions may favor both the mass production of cells by obtaining higher cell densities per unit culture volume on one side, and smooth cell-cell aggregation and three-dimension organogenesis in the absence of the disturbing pull of the force of gravity or of damaging shear forces due to agitation on the other side. One of the purposes of this proposal is to involve leading pharmaceutical and medical companies.

The objectives:
1st Development of procedures of in vitro organogenesis of pancreatic islets, thyroid tissue, liver, vessel, and cartilage.
2nd To select those engineered tissues that could take advantage of being continuously cultured under controlled conditions in microgravity. This will allow to better understand and to improve earth-bound bioprocesses as well as to develop innovative bioengineering in space.
3rd To define the requirements of the instrumentation (bioreactor) needed for this purpose. Preferentially a closed system under continuous monitoring, i.e. automatic, capable to sustain the production of organ-like structures that can be implanted into an organism in which they develop to fully functional tissues or organs. A useful frame could be the biotechnology mammalian tissue culture facility, BMTC, of ESA.
4th To set up procedures for the production of implants for medical applications.

The relevant issue behind the present proposal, is the variety of normal, differentiated mammalian and human in vitro biological systems available within the project. Such collaborative effort will give access to the most sophisticated and biotechnologically relevant in vitro cultured systems presently available. Those cultures, all within the long-term expertise of the proposers, will be used to validate both the theoretical approaches and the practical implementations to the bioreactor prototype(s) during its development.

The strategy adopted consists of a step by step approach:
1st All mammalian biological systems (single cells and tissues) will be optimized according to the team members’ specific expertise.
2nd The biological studies will be accompanied by ground-based simulations at 1 g, at simulated micro-gravity in clinostats (mainly in the random positioning machine) and at hypergravity in centrifuges.
3rd Design of a modular bioreactor consisting of a central „servicing unit“ and of modules specific for each biological system.
4th Optimization of the bioreactor to space laboratory requirements according to one selected system.
5th Semi-automation of the bioreactor.
6th Further expansion of the bioreactor to other systems.
7th Flight opportunities for hardware and biological tests: Biopack, Modular Cultivation System, Biolab, BMTC Spacehab, International Space Station, sounding rockets.
The phases:
Phase A  Developmental phase: Organ- or tissue-like structures are developed from single cells, applying conditions of microgravity.
Phase B  Optimization: The process is optimized to produce constructs that develop to functional organs / tissues after implantation in mammals.
Phase C  Industrial application: The results of phase B are taken to produce implants for organ / tissue regeneration for medical applications.
Phases A to C are started with the de novo articular cartilage tissue.

The applications oriented aspects of the research program:
Industrial parties interested in the development of tissues or organs, e.g. skin or liver, thyroid glands, etc., may join the topical team proposed in parallel as well as and this MAP project. Patents covering the principles of phases A to C may be licensed by industrial parties for the development of specific tissue and organ applications. Possible areas of application: implants, test systems for product development, e.g. pharmaceuticals, testing for quality control.

4.4 Project RPM
The RPM is an instrument that generates conditions simulating microgravity. It is an ideal tool for preparing experiments in real microgravity. Besides our own activities, there are several scientists visiting our lab to perform experiments in the RPM (see section 7).

4.5 Project tumor Spheroids
In collaboration with Daniela Grimm of the Institute of Clinical Pharmacology and Toxicology, Benjamin Franklin Medical Center, FU Berlin, we are studying the effects of simulated microgravity on the human follicular thyroid carcinoma cell line ML-1. One of the objectives is to cultivate three-dimensional tumor spheroids to use them as a model of solid tumor. Spheroids are aggregates of cells of 0.1-0.5 mm diameters. In addition, several biochemical parameters are determined.

4.6 Gradient Bioreactor Study
In the frame of the future activities on ISS, ESA has decided to promote bioreactor technology. One of such activities is the development of a gradient bioreactor for the growth of cells and tissues under the influence of concentration gradients of nutrients, activation factors etc. The phase A of the study has been concluded in March 2001. The phase B will start early 2002.

4.7 Osteoclasts
Monici and Bernabei of the University of Florence have developed an innovative technology to study in vitro the interaction bone/osteoclasts under physiological conditions. It consists of the incubation of an osteoclastic cell line (established by M. and B.) with slices of calf bone in which a rut has been traced. Bone resorption is measured by means of a profilometer (bone resorption assay). Such technology is now applied to experiments conducted in the RPM.
4.8 BIOTESC (Biotechnology Space Support Center)
In 2000 ESA and the ETHZ have signed a contract for the establishment of a user operation and support center (USOC) for biological and biotechnological projects on ISS. Essentially, BIOTESC will provide support to the users of BIOLAB the biological facility that will be installed on ISS. Such activity will be coordinated with other users centers in Cologne, Naples, Toulouse, Madrid, Copenhagen, Trondheim and Amsterdam.

5. RESULTS

5.1 Biopack
The first flight of Biopack in the Shuttle mission STS-107 has been delayed for various reasons to July 2002. An experiment sequence test was conducted in September. A number of problems appeared that forced to repeat the test for some of the activities in March 2002. Also the preparation of the instrumentation of the experiment "Yeast cells: stress under microgravity" (PI I. Walther) encountered several problems mainly due to the late delivery of components by Mecanex. Nevertheless, the flight hardware is now ready for the flight.
The protocols and instrumentation of the experiment "Role of interleukin-2 receptor in signal transduction and gravi-sensing threshold of T lymphocytes" have been refined in collaboration with the co-investigators in the USA, M. Hughes-Fulford, and in Italy, P. Pippia.
The development of the apparatus for the third experiment “Study of cell movements of monocytes and interactions with T cells in 0 g” has started after the financial support has been approved by the PRODEX Program Committee. A contract was signed with EMPA, Dübendorf.

5.2 Maser 9
Also this mission had to be delayed to March 2002 due to late delivery of the instrumentation of the two experiments by Fokker Space, Leiden. Such instruments underwent extensive laboratory tests and modifications so that we are ready for the flight.
The protocol of the experiment “Study of expression of early genes in T cells in 0 g” has been finalized in collaboration with R. Negri (specialist in Microarray technology, Uni. Rome) and with the team in Sassari (P. Pippia).
The protocol of the experiments “Study of genetic expression and cytoskeleton structure of chondrocytes in microgravity” has been prepared in collaboration with R. Dreier (specialist in cytoskeleton analysis, Uni. Münster) and S. Berardi (specialist in genetic expression of chondrocytes, Sulzer Medica).
Vibration tests were conducted at Fokker Space in July.

5.3 MAP
The SBG activity consisted of the coordination of the project, the preparation of the investigations on MASER 9 and of the conduction of experiments with chondrocytes in simulated microgravity in the RPM.
A progress meeting was held in January in Zurich, three further meeting were hold via teleconference. The experiments in the RPM delivered interesting data summarized below.
Pig chondrocytes were prepared from joints obtained from the slaughter house by cutting thin slices of cartilage and exposing them to degradation with pronase and collagenase for 24 h at 37°C in a spinning bottle according to a procedure developed in-house by Sulzer Medica.

The cells were incubated in DMEM medium supplemented with 10% fetal calf serum, insulin 1µg/ml, vitamin C 50 µg/ml, penicillin 100 U/ml and streptomycin 100 µg/ml. A concentration of either 50x10^6 cells/ml or of 120x10^6 cells/ml was used. The cultures were sealed in de novo inserts fixed with a stainless steel clamp in a cylindrical chamber (3 cm of diameter, 4 cm height) made of polycarbonate. The chambers are filled with 30 ml medium and carefully sealed with the cap to avoid air bubbles. Exhausted medium is replaced with fresh medium every 2-3 days. At the end of the incubation time cells were chemically fixed with 4% paraformaldehyde.

The De novo insert, provided and patented by Sulzer Medica consists of a cylinder of polycarbonate of 8 mm diameter either 5 mm or 2 mm height sealed on both sides by a membrane permeable to the medium but not to the cells.

The histological analysis was performed on specimen of cartilages grown in the RPM as well as in 1 g controls using the alcian blue, Masson-trichrom and Saphranin O stainings. Solid and compact specimen of cartilage were obtained after 2 or 3 weeks of culture either at 1 g or under conditions simulating low-g in the RPM. As shown in the Fig. 1 there are clear morphological differences between the static (panels right) and RPM-samples (panels left). First, the cartilage from the RPM is round-shaped, almost spherical, whereas that grown at 1 g reflects the geometry of the de novo insert (panels top). Second, the histological analysis reveals a more compact cellular structure in the RPM than in the static 1 g samples (panels bottom). Third, the arrangement of the cells in the cartilage appears arranged in a more “ordered” geometry in the RPM (panels middle). In fact, whereas at 1 g the cells are distributed at random in the intercellular matrix, in the RPM the cells appear arranged in lines (see arrow in middle panel left of the Fig. 1).

Although these data are preliminary and only qualitative, and need further verification, they indicate that the structure of the cartilage formed under simulated low-g is somehow different from that obtained at 1 g. At this point It cannot be said, however, whether this finding may lead to improved quality of transplants for humans or not. Nevertheless such experiments will contribute to the understanding of the biological mechanisms of chondrocyte differentiation. The results are reported in detail in Conza et al., 2001.
Figure 1. Cartilages formed from pig chondrocytes cultured for 21 d (panels top and middle, $50 \times 10^6$ cells/ml, *de novo* insert 5 mm deep) and 14 d (panels bottom, $120 \times 10^6$ cells/ml, *de novo* insert 2 mm deep) under conditions simulating microgravity in the RPM (panels left) and at 1 g (panels right).
5.4 Collaborative experiments in the RPM
Several international teams are visiting our laboratory to carry out collaborative investigations under simulated 0 g conditions.
With the team of Daniela Grimm of the Freie Universität Berlin we have investigated the behavior of human thyroid carcinoma cells. The results are in print in the FASEB Journal. The abstract of the article follows below:
This focuses on the effects of simulated microgravity (0g) on the human follicular thyroid carcinoma cell line ML-1. Cultured on a three-dimensional clinostat, ML-1 cells formed three-dimensional MCTSs (MCTS diameter: 0.3±0.01 mm). After 24 and 48 h of clinorotation, the cells significantly decreased tT3 and tT4 secretion but up-regulated the thyroid-stimulating hormone-receptor expression as well as the production of vimentin, vinculin, and extracellular matrix proteins (collagen I and III, laminin, fibronectin, chondroitin sulfate) compared with controls. Furthermore, ML-1 cells grown on the clinostat showed elevated amounts of the apoptosis-associated Fas protein, of p53, and of bax but showed reduced quantities of bcl-2. In addition, signs of apoptosis became detectable, as assessed by terminal deoxynucleotidyl transferase-mediated dUTP digoxigenin nick end labeling, 4′6-diamidino-2-phenylindole staining, DNA laddering, and 85-kDa apoptosis-related DNA fragments. The latter ones resulted from enhanced 116-kDa poly(ADP-ribose)polymerase (PARP) activity. These observations suggest that clinorotation elevates intermediate filaments, cell adhesion molecules, and extracellular matrix proteins and simultaneously induces apoptosis in follicular thyroid cancer cells. In conclusion, our experiments could provide a regulatory basis for the observation that astronauts show low thyroid hormone levels after space flight, which may be explained by the increase of apoptosis in thyrocytes as a result of simulated 0g.
With Monica Monici and Pietro Bernabei of the University of Florence we were able to show that osteoclastic bone resorption is significantly enhanced in simulated microgravity.

5.5 Gradient Bioreactor
The phase A of the study has been successfully concluded. The feasibility of a gradient bioreactor has been demonstrated. Phase B will start early 2002.

5.6 BIOTESC
Several meetings were held in 2001 with the representative of the European USOC centers in order to define the activities and the requirements for optimum support of the users of the ISS.

6. LECTURING
A. Cogoli: Vorlesung 01-642 GL der Immunologie, 2 Wochenstunden im SS

7. VISITING SCIENTISTS
29-31 January: Prof. Saverio Ambesi, Dr. Giuseppina Perrella, UNI Udine
12-24 February: Dr. Grazia Galleri, UNI Sassari
8-11 March: Dr. Monica Monici, Dr. Pietro Bernabei, UNI Firenze
7-8 May: Dr. Daniela Grimm, FU Berlin
12-13 July:  Prof. Hampp, UNI Tübingen
27-29 August:  Dr. Giuseppina Perrella, Uni Udine
24.-26 September Dr. Giuseppina Perrella, Uni Udine
1.-4. November Dr. Monica Monici, Dr. Pietro Bernabei, UNI Firenze
19.-23. November Dr.Daniela Grimm, Dr. Peter Kossmehl, FU Berlin

8. PUBLICATIONS


9. LECTURES, DEMONSTRATIONS, COMMITTEES

A. Cogoli

27 January  Zürich, Space Forum, Schweizerisch Raumfahrt Vereinigung „Arbeiten im Weltraum (together with Claude Nicollier)“
29 January  Davis, California, Symposium on Future of chronic acceleration “Chronic acceleration is an important element of gravitational and space cell biology”
2 March  Oberglatt, Generalversammlung Sportverein Rehwinkel
„Weltraumbiologie“

4 April  University of Florence
“Biologia Spaziale: Dalla ricerca di base alla biotecnologia”

24 April  Budapest, Intern. Soc. for Gravitational Physiology
“Tissue enigineering in Space”

10 July  18. Int. Soc. for Biomechanic, Zürich „Space Day“
“Introduction of the Space Biology Group”

28 September  Baynuls sur Mer, Biennial ELGRA Meeting
“Tissue engineering in Space” (contributed paper)

26 October  Madrid, Universidad Autonoma, Topical Team of ESA “Sample preservation”
“Preservation/Fixation of mammalian cells”

8 November  University Zürich, Volkshochschule des Kantons Zürich
„Weltraumbiologie: Von der Grundlagenforschung zur Biotechnologie“

9 November  Technopark Zürich, Treffen Swiss Technology Transfer
„Präsentation des Forschungsprogrammes der Gruppe für Weltraumbiologie der ETHZ“ (Together mit M. Cogoli-Greuter)

I. Walther

24 April  Budapest, Intern. Soc. for Gravitational Physiology
“Space bioreactors: their use, their future”

M. Cogoli-Greuter

28 May  Biarritz, France: 15th ESA Symposium on European Rocket and Balloon Programmes and Related Research. National report
“Swiss scientific balloon and sounding rocket experiments and related research in 1999-2001”

25-28 September  Banyuls sur mer (France), Biennial Meeting of the European Low Gravity Organisation: Co-organiser of the scientific programme; welcome address during opening ceremony, closing remarks; ELGRA General Assembly, president report

Visits of Schools:

14 June  Dr. Raebers Höhere Handelsschule, Zurich
26 September  Kantonsschule Engi, Steintischstrasse 10, Zurich
21 November  Kantonsschule Enge (HES), Zürich

Public relations activities

27 March  Shot of a video for ESA to present the MAP project for ISS (A. Cogoli, I. Walther, H. Bellwald)

16 May  Swiss Radio DRS: Life interview in „Treffpunkt“ (A. Cogoli)

February  Weekly magazine Schweizer Familie: Interview with A. Cogoli

October 2001 - March 2002  Museum für Gestaltung, Zurich: Exposition „All design, Leben im Weltraum“

July  Students experiment selected by ESA for rollercoaster flight: fluid dynamics in the
LIDIA chambers to be used in MASER 9

Committees
A. Cogoli
Member of the Federal Advising Committee for Space Affairs,
Member of the PRODEX Program Committee,
Member of the European Space Science Committee of European Science Foundation.

M. Cogoli
President of the European Low Gravity Research Association (ELGRA),
Swiss representative of the Programme Advisory Committee (PAC) on Special Projects concerning the Launching of Sounding Rockets of ESA,
Member of the Life and Physical Science Advisory Committee of ESA

I. Walther
Member of the Commission for Space Research of the Swiss Academy of Natural Sciences

10. ACRONYMS

ASI Agenzia Spaziale Italiana
BIOTESC Biotechnology Space Support Center
BMTC Biotechnology Mammalian Tissue Culture facility
DLR Deutsche Versuchsanstalt für Luft- und Raumfahrt
Con A Concanavalin A
ESA European Space Agency
ESTEC European Space TEchnology Center
FFM Free Fall Machine
HTS High Technology Systems
IL Interleukin
IWG Investigators Working Group
ISS International Space Station
LIDIA Liquid Dispenser Assembly
MAP Microgravity Application Program
MASER Material Science Experiment Rocket
NASA National Aeronautics and Space Agency
PI Principal investigator
PRODEX PROgram of Development of EXperiments
RPM Random Positioning Machine
RT-PCR Reverse Transcriptase Polymerase Chain Reaction
STS-... Space Transportation System (Space Shuttle) Flug Nr. ...