

Maintaining Human Physiology in Space



Group 6:

Gabriela Debesa Tur

J r mie Beghin

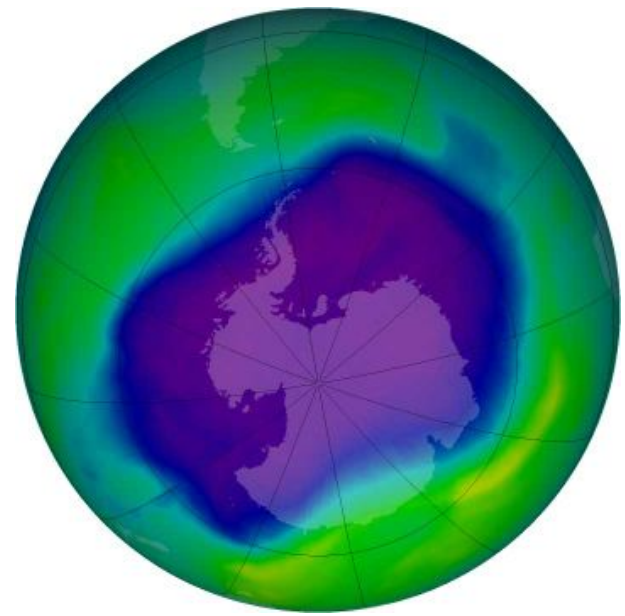
Luke Webster

Michael Arzt

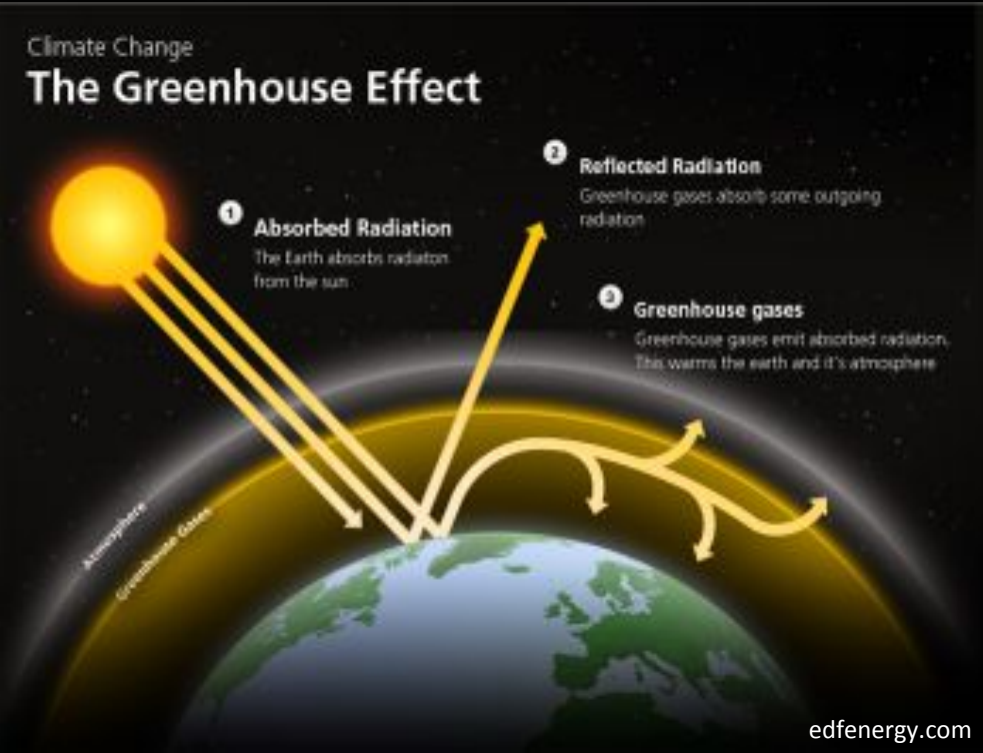
Quan Zhang



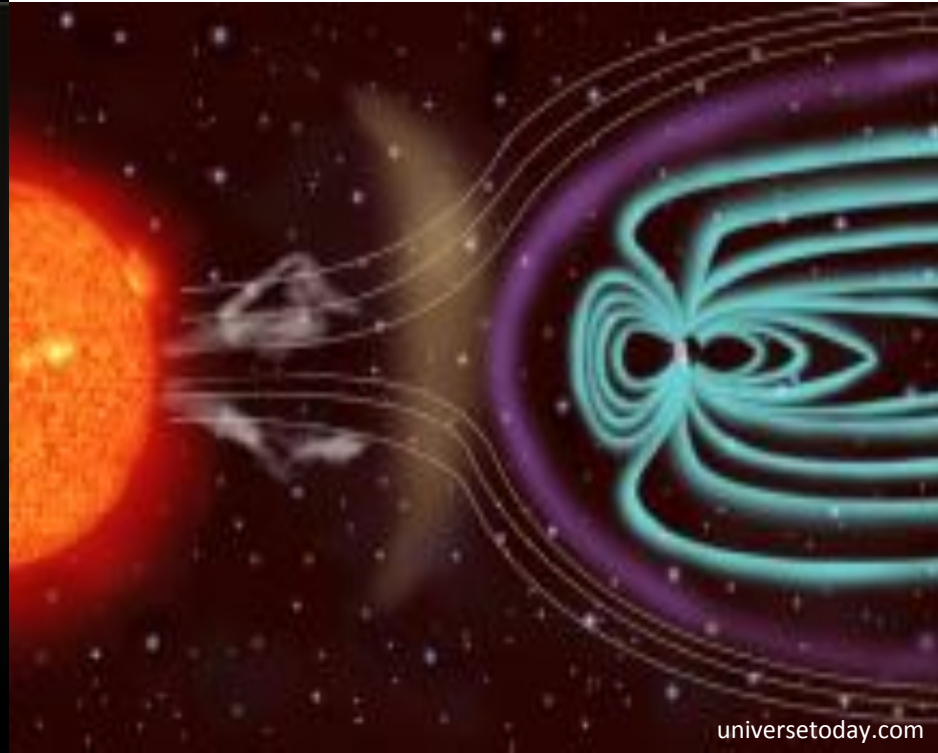
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NASA



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Earth

VS

Space



- Gravity
- Greenhouse effect
- Average $T = 15\text{ }^{\circ}\text{C}$
- Atmospheric pressure = 1013.25 hPa
- Protection from solar radiation (O_3)
- Air (N_2 , O_2 , Ar, CO_2 ,...)

- Microgravity
- Extreme T variation ($150\text{ }^{\circ}\text{C}$ to $-120\text{ }^{\circ}\text{C}$)
- Intense vacuum
- Radiation
- No air to breathe

Kármán line @ 100km
(from FAI = the world air sports federation)

Psychology

Nervous System

Vestibular System



Muscles

Bones

Circulatory System

Reproductive System

Immune System

3 BEHAVIORAL HEALTH AND PERFORMANCE

- 5 Risk of Adverse Behavioral Conditions and Psychiatric Disorders
- 5 Risk of Performance Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team
- 5 Risk of Performance Errors Due to Fatigue Resulting from Sleep Loss, Circadian Desynchronization, Extended Wakefulness, and Work Overload

3 EXPLORATION MEDICAL CAPABILITY

- 5 Risk of Unacceptable Health and Mission Outcomes Due to Limitations of In-Flight Medical Capabilities

3 HUMAN HEALTH COUNTERMEASURES

- 5 Risk Factor of Inadequate Nutrition
- 5 Risk of Bone Fracture
- 5 Risk of Cardiac Rhythm Problems
- 5 Risk of Clinically Relevant Unpredicted Effects of Medication
- 5 Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems
- 5 Risk of Crew Adverse Health Event Due to Altered Immune Response
- 5 Risk of Decompression Sickness
- 5 Risk Of Early Onset Osteoporosis Due To Spaceflight
- 5 Risk of Impaired Control of Spacecraft, Associated Systems and Immediate Vehicle Egress Due to Vestibular/Sensorimotor Alterations Associated with Space Flight
- 5 Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance
- 5 Risk of Injury from Dynamic Loads
- 5 Risk of Intervertebral Disc Damage
- 5 Risk of Orthostatic Intolerance During Re-Exposure to Gravity
- 5 Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
- 5 Risk of Renal Stone Formation
- 5 Risk of Spaceflight-Induced Intracranial Hypertension/Vision Alterations

3 SPACE HUMAN FACTORS AND HABITABILITY

- 5 Risk of Adverse Health Effects Due to Alterations in Host-Microorganism Interactions
- 5 Risk of Adverse Health Effects of Exposure to Dust and Volatiles During Exploration of Celestial Bodies
- 5 Risk of an Incompatible Vehicle/Habitat Design
- 5 Risk of Inadequate Critical Task Design
- 5 Risk of Inadequate Design of Human and Automation/Robotic Integration

3 Element

5 Risk

5 Gap

5 Task

Immunological studies

Immune suppression of human lymphoid tissues and cells in rotating suspension culture and onboard the International Space Station

Wendy Fitzgerald • Silvia Chen • Carl Walz •
Joshua Zimmerberg • Leonid Margolis •
Jean-Charles Grivel

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5-Lipoxygenase-dependent apoptosis of human lymphocytes in the International Space Station: data from the ROALD experiment

Natalia Battista,^{*1} Maria A. Meloni,^{†1} Monica Bari,[‡] Nicolina Mastrangelo,[‡]
Grazia Galleri,[†] Cinzia Rapino,[°] Enrico Dainese,[°] Alessandro Finazzi Agrò,[‡]
Proto Pippia,[†] and Mauro Maccarrone^{*,§,||,2}

^{*}Department of Biomedical Sciences, University of Teramo, Teramo, Italy; [†]Department of Physiological, Biochemical, and Cellular Sciences, University of Sassari, Sassari, Italy; [‡]Department of Experimental Medicine and Biochemical Sciences and [§]Center for Space Biomedicine, University of Rome Tor Vergata, Rome, Italy; and ^{||}Santa Lucia Foundation, Rome, Italy

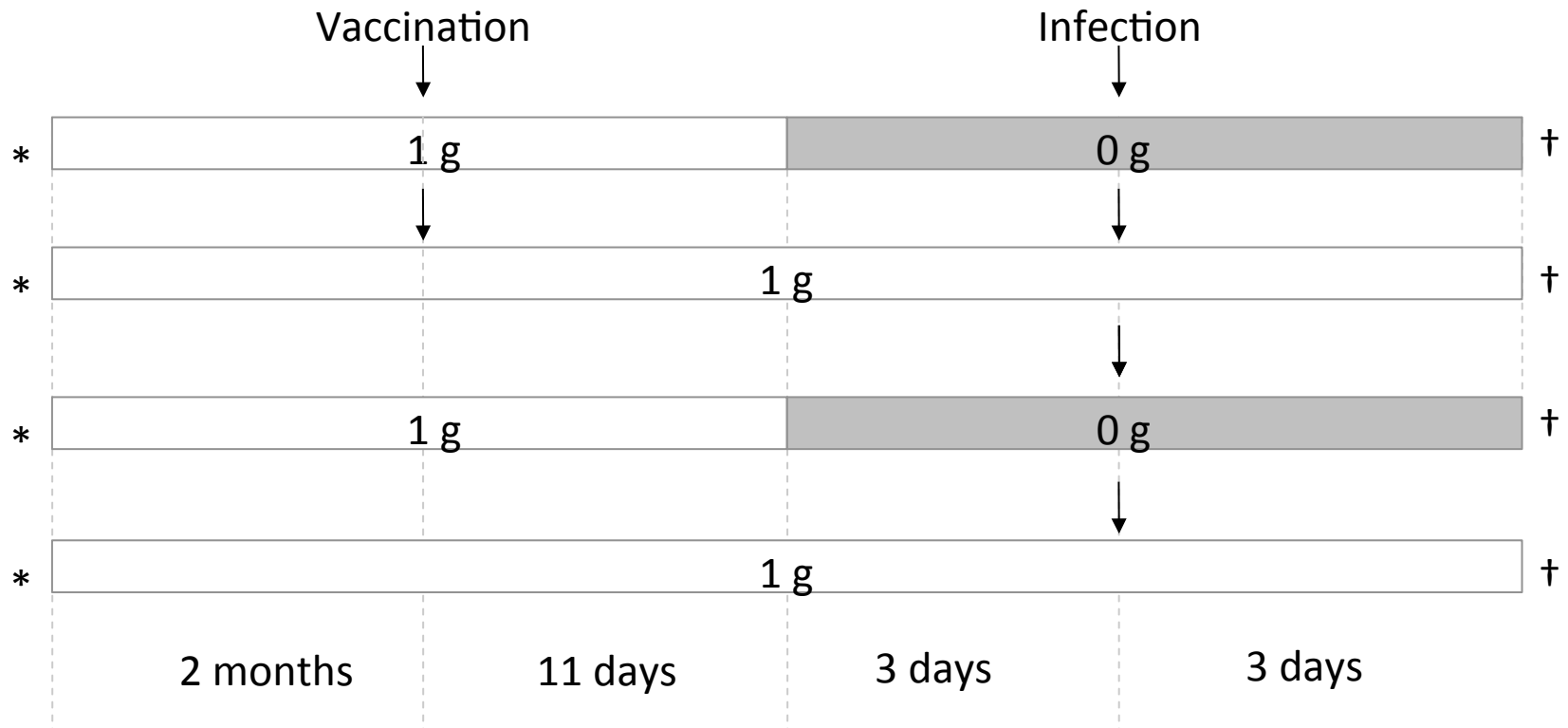
Immunological Studies

Experiment 1

Hypothesis: Vaccination before space flight does not protect from in-flight infection

Model system: Mouse

Pathogen: Influenza (mouse-specific)



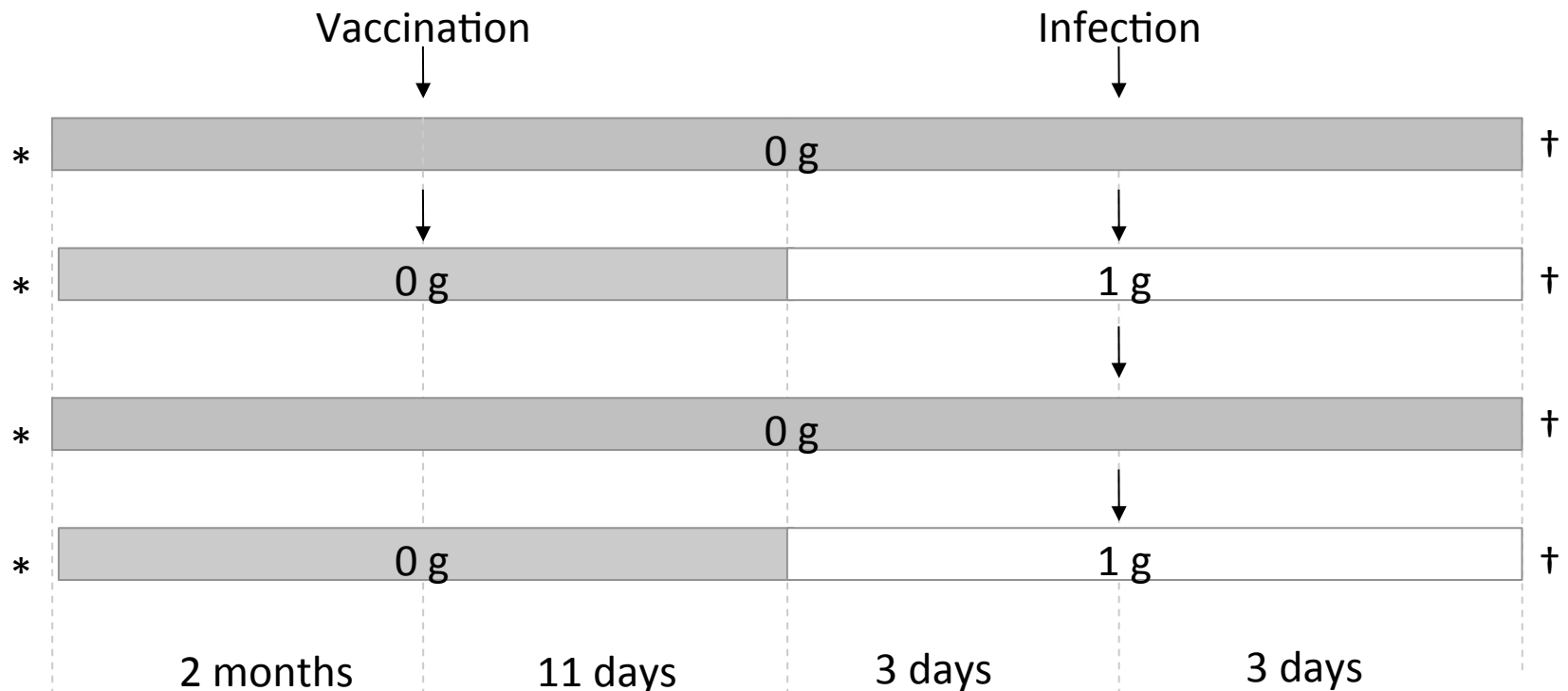
Immunological Studies

Experiment 2

Hypothesis: Vaccination is not effective if administered during space flight

Model system: Mouse

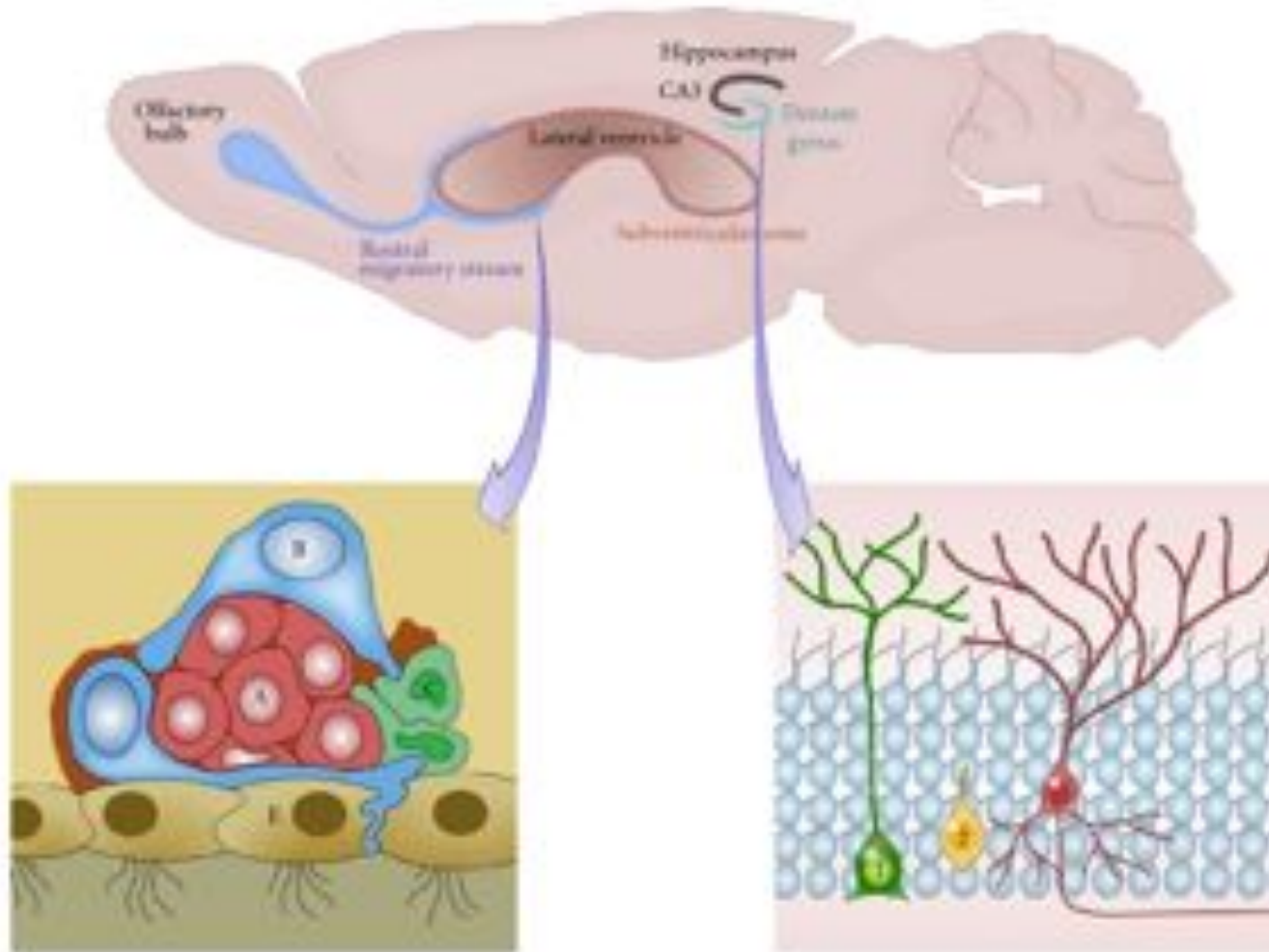
Pathogen: Influenza (mouse-specific)



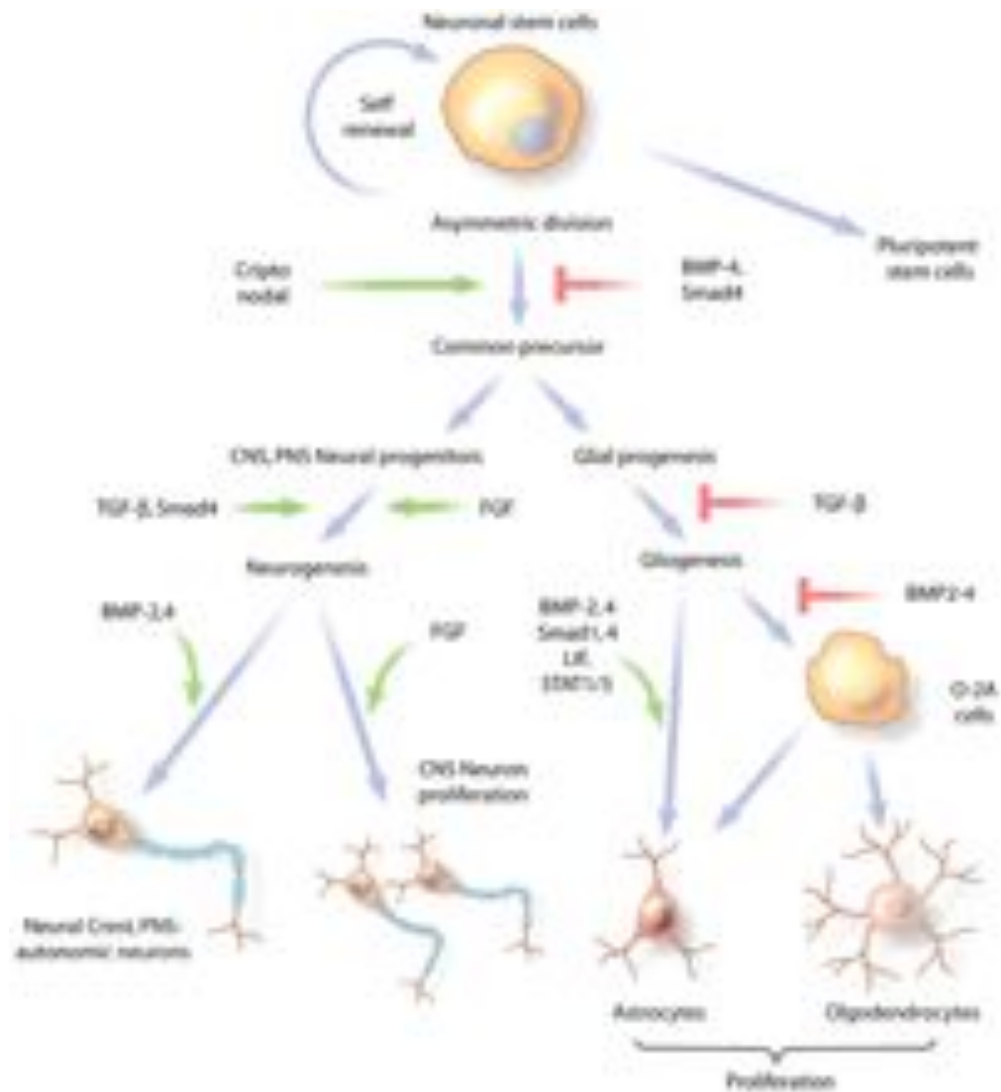
Parameters

- Memory cells (T-cells, B-cells)
- Humoral immune response (specific antibody)
- Cellular immune response (cytotoxicity)
- Cytokines (IL-2, IFN- γ)
- Titer of virus

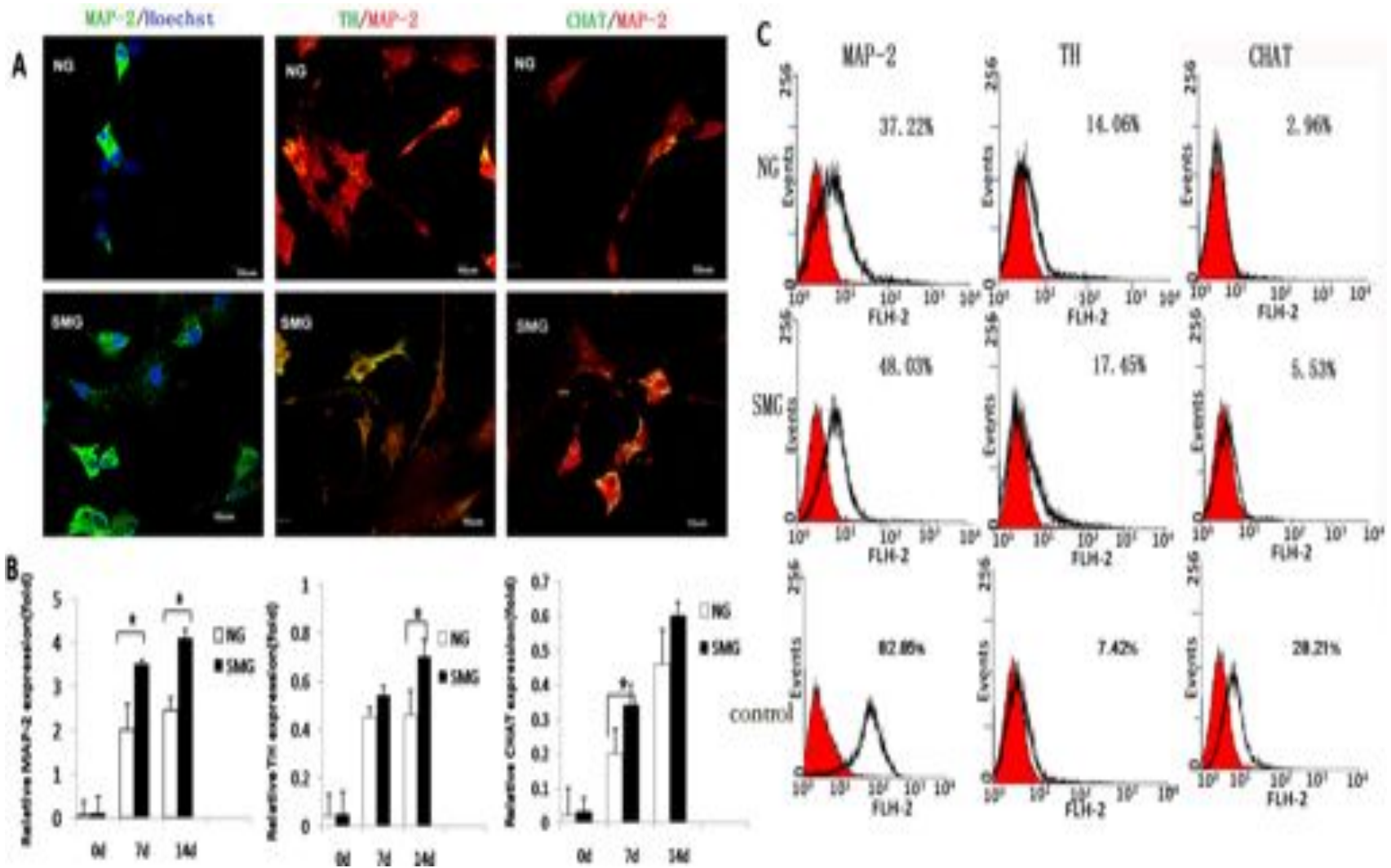
Adult Neurogenesis



Adult Neurogenesis

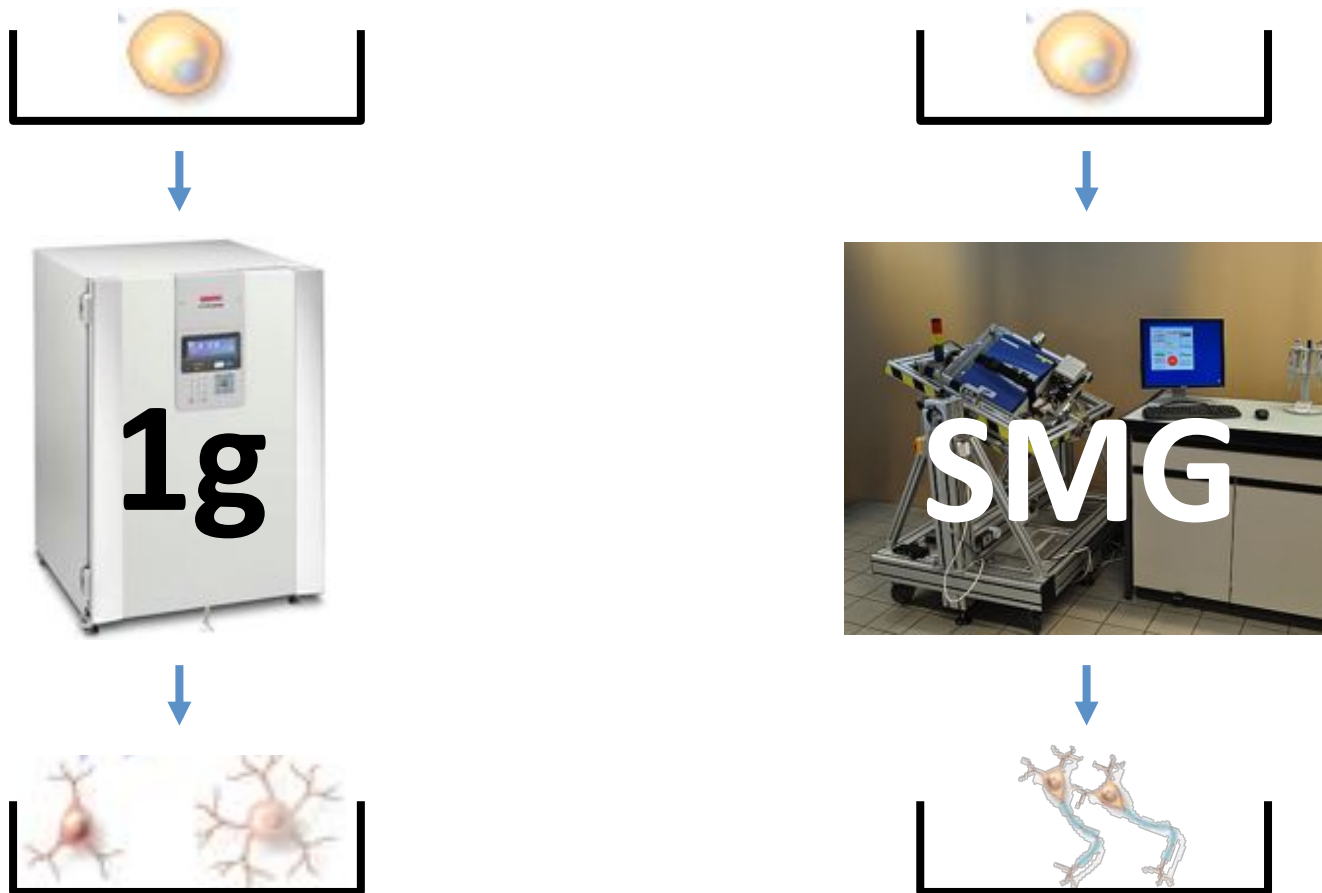


Stem Cells in Simulated Microgravity



Hypothesis: Microgravity drives neural stem cells (NSCs) towards differentiation into neurons.

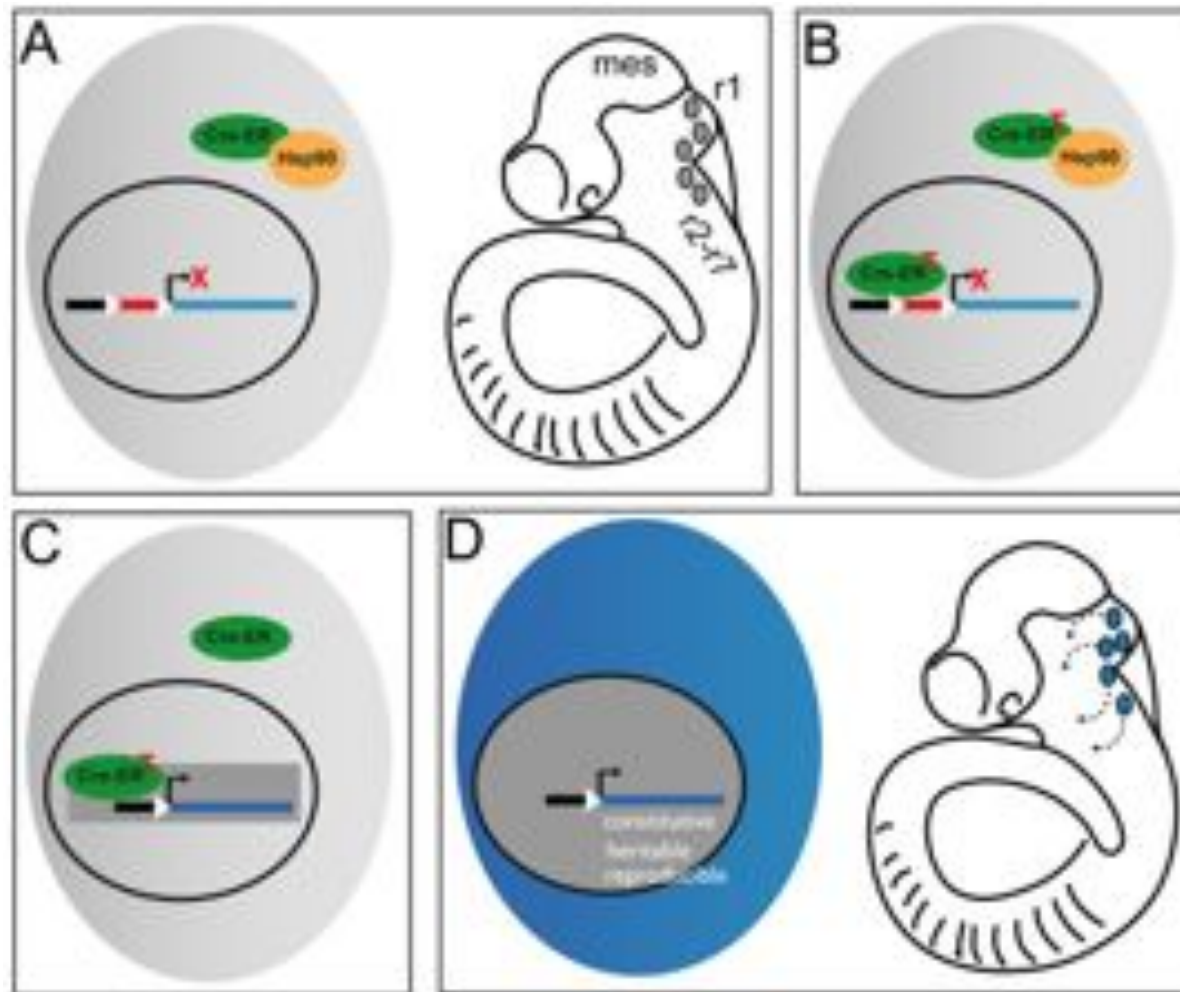
1. In vitro experiment: Cultivation of NSCs in simulated microgravity (SMG)



Immunostaining, qRT-PCR: neuronal vs. glial markers? Ratio?

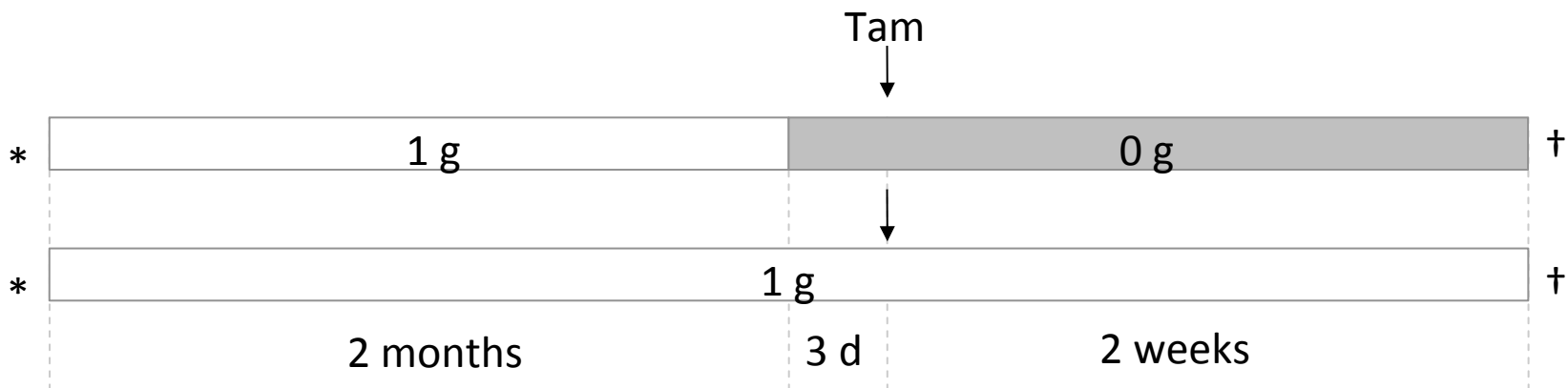
Hypothesis: Microgravity drives neural stem cells (NSCs) towards differentiation into neurons.

2. In vivo experiment: Fate mapping of adult NSCs

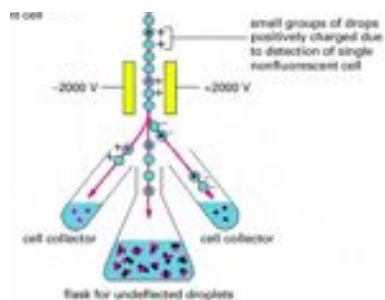


Hypothesis: Microgravity drives neural stem cells (NSCs) towards differentiation into neurons.

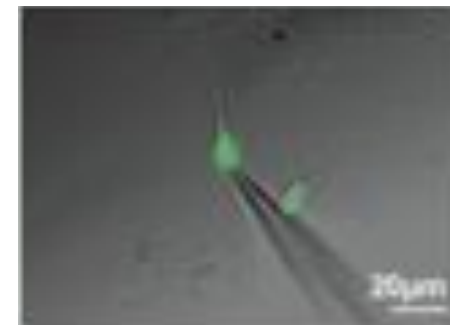
2. In vivo experiment: Fate mapping of adult NSCs



Fluorescence Microscopy:
- Cell numbers and location?
- Cell type? (immunostaining)



FACS/RNAseq:
- expression profiles?



Electrophysiology:
- functional integration?

Perspectives

- Immunological Study
 - Production of vaccines specifically for space travel
 - Increase the dose of molecular immunogenicity in the vaccine
 - Use the new type of adjuvant
- Neurogenesis Study
 - Understand effect of microgravity on neurogenesis
 - Maintain neuronal homeostasis during long space flight
 - Developing / injured nervous system?

Maintaining Human Physiology in Space

A photograph of an astronaut in a white spacesuit floating in space, with the Earth's blue and white horizon in the background. A large white speech bubble with a blue outline is positioned in the center, containing the text 'Thank you!'. The background shows the complex structure of a space station or shuttle in orbit.

Thank you!

Group 6:

Gabriela Debesa Tur

Jeremie Beghin

Luke Webster

Michael Arzt

Quan Zhang

Fluorescence-Activated Cell Sorting (FACS)

