Seed resilience to extreme conditions in space

Research Overview

One of the aims of the Seed and Stress Biology group is to understand traits underlying pre-germination survival. This includes identifying traits that determine extreme stress tolerance, such as conditions found in space environments. Here we provide an overview of current and potential future research projects in this area.

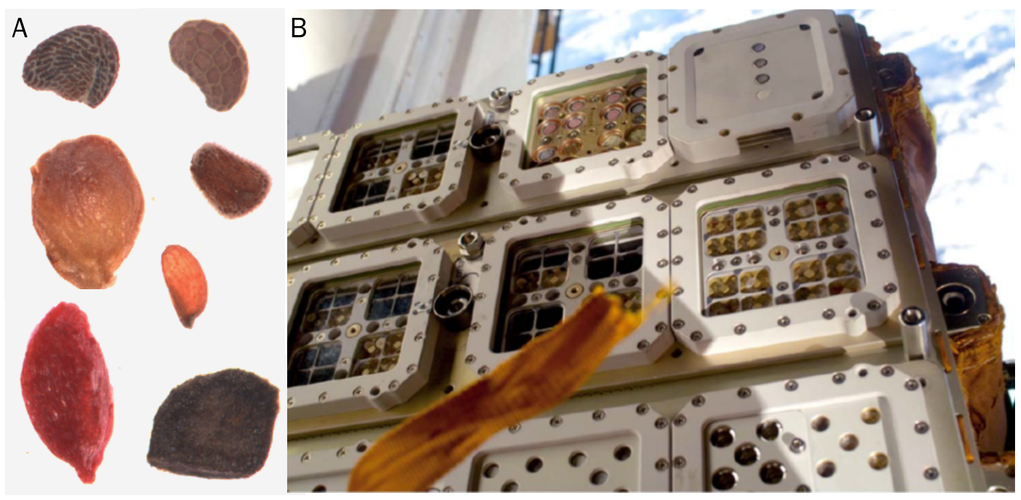


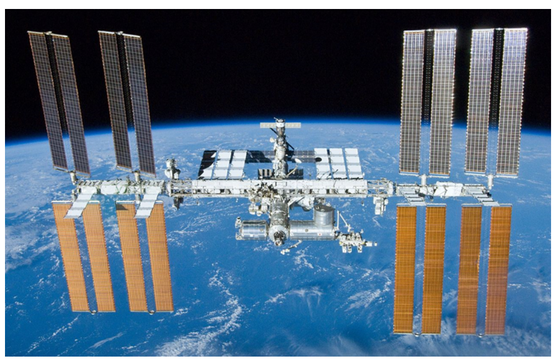
Fig. 1: (A) Seeds representative of several of the proposed GENESISS species, (B) Previous EXPOSE facility on the International Space Station (Tepfer et al., 2012)

Project 1: GENESISS (Germination after Extreme Natural Exposure of Seeds on the International Space Station). This project is led by RBG, Kew and aims to investigate, in collaboration with MSSL (UCL), to which degree seeds of different species vary in their resilience to the extreme environmental conditions in space and the traits underpinning this resilience.

GENESISS will expose seeds from 24 species (covering a wide range of plant diversity and seed traits) to vacuum (anoxia, ultra-drying), radiation and temperature fluctuations for over a year. During this time, some of the volatiles released by seeds under vacuum will be detected and tracked over time by a miniature space-based Mass Spectrometer developed by MSSL (UCL).

Experiments related to vacuum conditions found in space have relevance to seed storage on Earth as well, as seeds of some plant species are found to have improved longevity under storage that involves ultra-drying or anoxia (Visscher et al., 2016).

Project 2: SV-ISS (Seed Vigour In Space Seeds). This project is led by RBG, Kew and aims to understand, in collaboration with RHUL and Tozer Seeds, how seed vigour from extremophile and polyploid plant species responds to spaceflight (inside the ISS) compared to species with lower stress tolerance and ploidy level.



Project 3: ALEPH-1 This project is led by Australian space start-up Lunaria One, with RBG Kew as collaborator. It aims to germinate and grow seeds from a range of species inside the ALEPH-1 payload once it reaches the lunar surface. Our expertise will help to identify candidate plant species with seed germination characteristics that meet the objectives and restrictions of the payload.

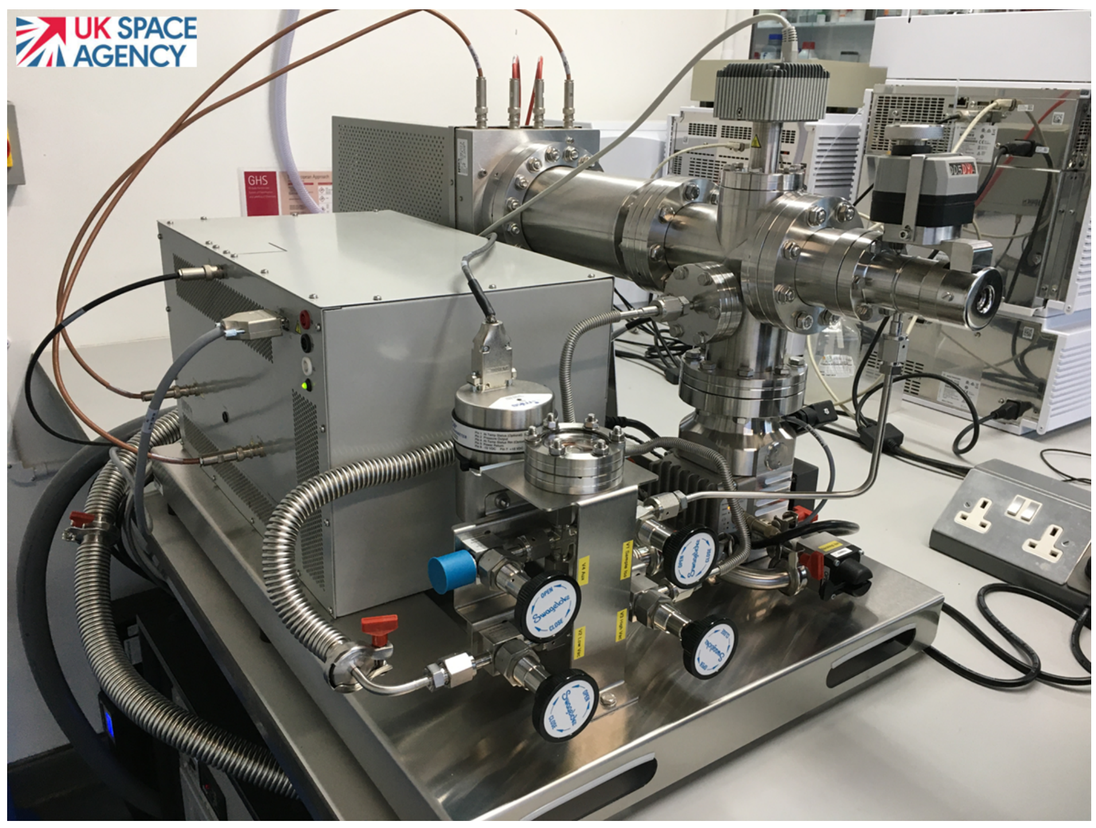


Fig. 2: Vacuum chamber for seed samples with options for analyses of seed volatiles released under low pressure: Mass Spectrometry (MS) and Gas Chromatography Mass Spectrometry (GC-MS). The equipment and associated GENESISS pre-flight experiments are funded by the UK Space Agency (UKSA).

Potential future research opportunities:

Lunar Artemis Programme:

a) METIS: The Multifunctional Exposure Test bed In deep Space (METIS) is an ESA-led facility for the upcoming Gateway platform in lunar orbit. METIS will enable research teams to fly samples external to Gateway and expose them to deep space conditions outside of low Earth orbit and beyond the magnetosphere.

b) Lunar regolith sample return: If opportunities arise, we propose to investigate the seed germination potential of a range of plant species sown in pure regolith samples that will be collected and returned to Earth from the Moon.

Lunar regolith filters: This project is led by Imperial College London with RBG Kew as potential collaborator and aims to assess whether plants could provide materials for regolith filters used in future human habitats on the Moon.

Lunar Gateway concept

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References:

Tepfer, D., Zalar, A., & Leach, S. (2012). Survival of plant seeds, their UV screens, and nptII DNA for 18 months outside the International Space Station. Astrobiology, 12(5), 517–528. https://doi.org/10.1089/ast.2011.0744

Visscher, A. M., Seal, C. E., Newton, R. J., Frances, A. L., & Pritchard, H. W. (2016). Dry seeds and environmental extremes: consequences for seed lifespan and germination. Functional plant biology : FPB, 43(7), 656–668. https://doi.org/10.1071/FP15275