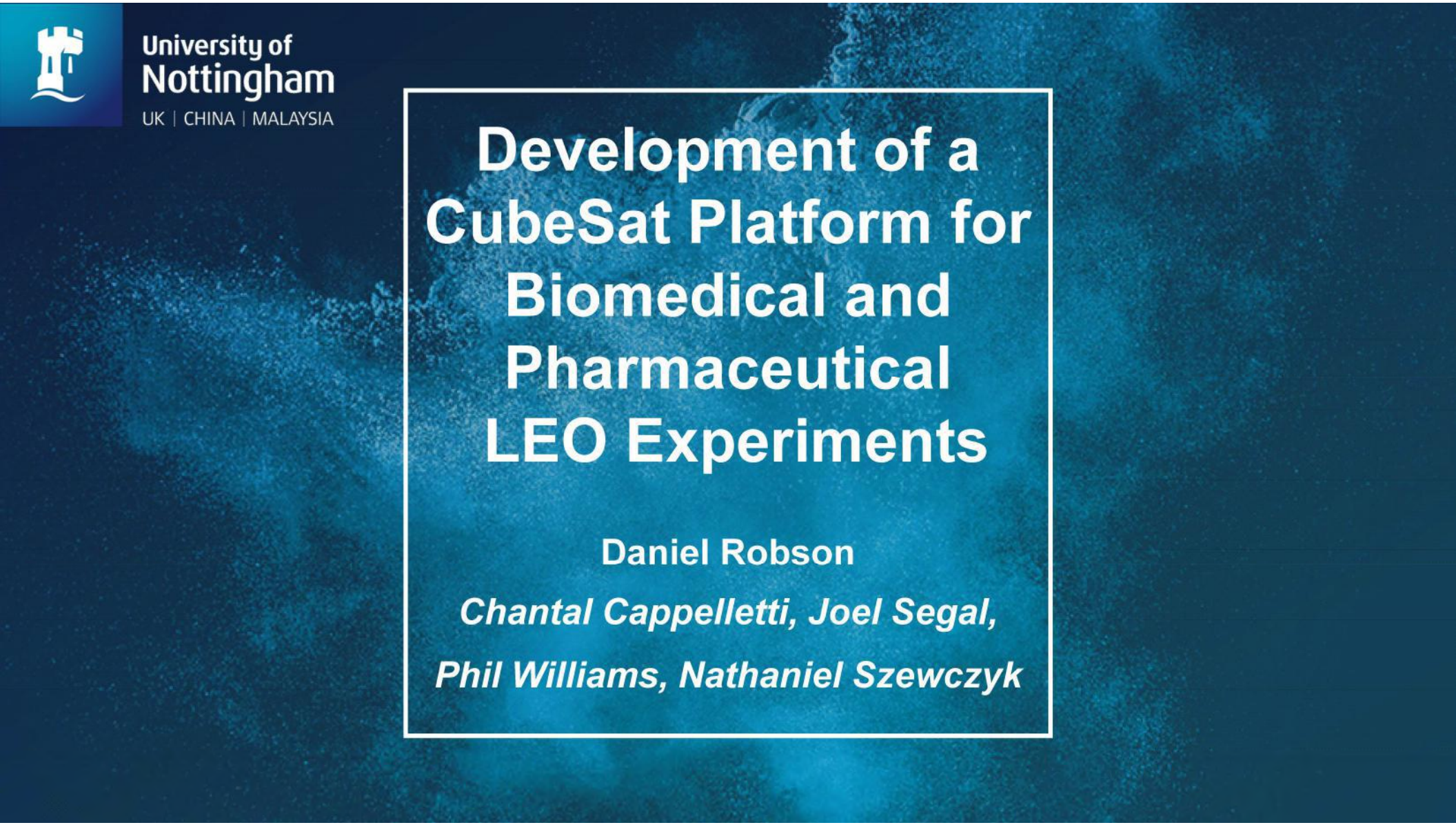
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Development of a CubeSat Platform for Biomedical and Pharmaceutical LEO Experiments
Daniel Robson
Chantal Cappelletti, Joel Segal,
Phil Williams, Nathaniel Szewczyk

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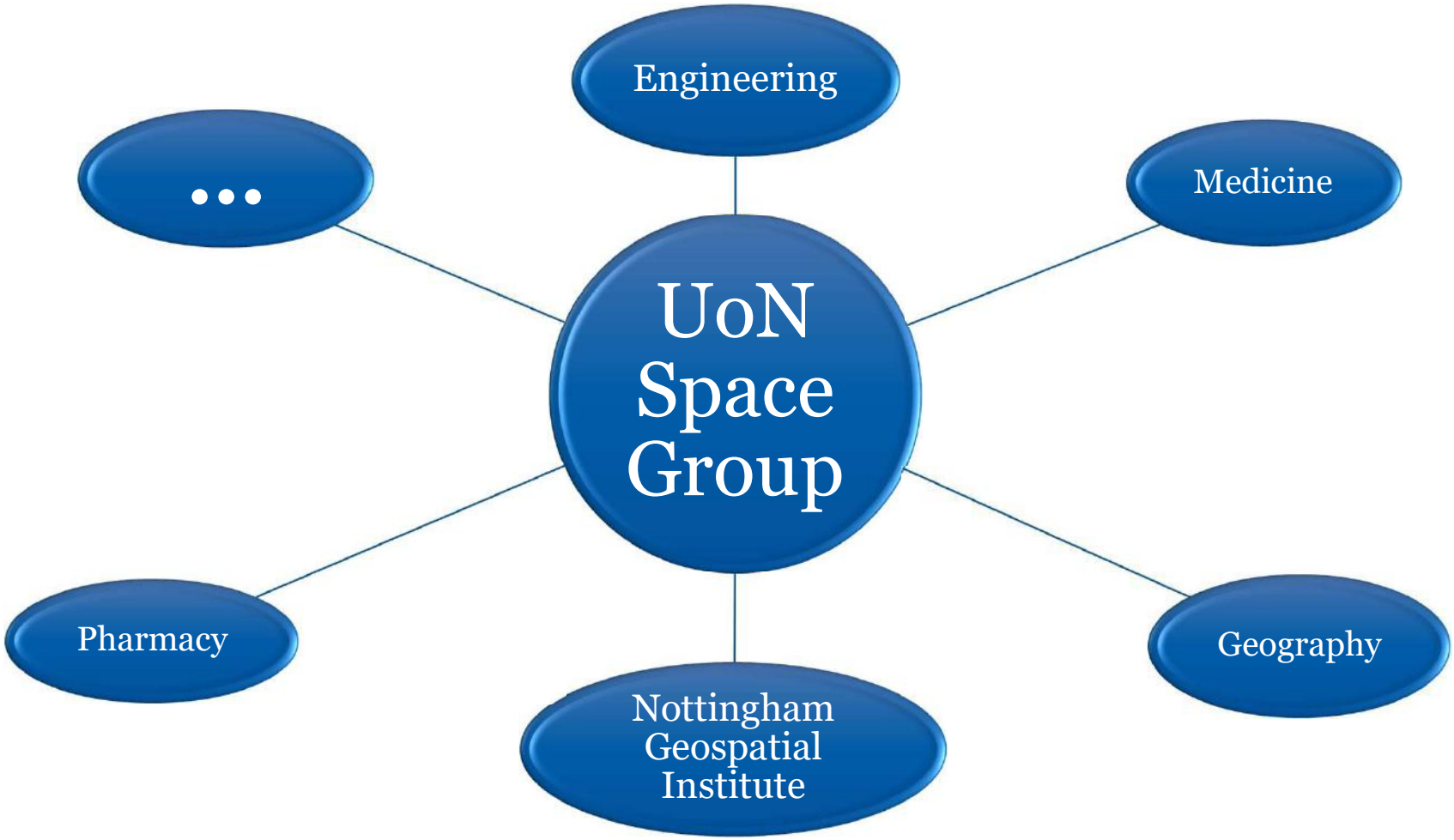
University of Nottingham Space Group



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EPSRC Funded Astropharmacy & Astromedicine

Bacterial and immunological challenges in space flight

Liposomes mimicking halophilic archaea cell membrane for antibacterial therapy in space

UoN Astrobiology CubeSat design and development

Synthetic biology for on-demand production of therapeutics

The roles of muscle contraction and insulin on restoring glucose uptake with novel pharmaceutical and engineering solutions

Foods for Space: Late stage customization of food materials in extreme environments

Global Top 10 School

THE UNIVERSITY of ADELAIDE

ASTRO PHARMACY
ASTRO MEDICINE

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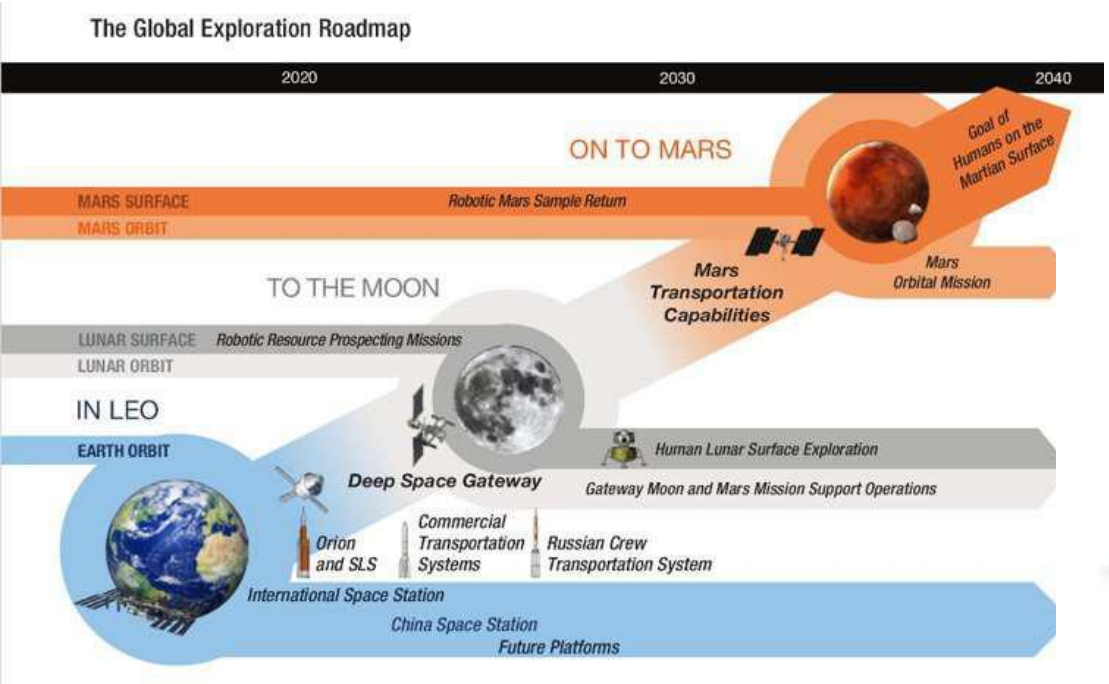
Biomedical Applications for Life On & Off Earth



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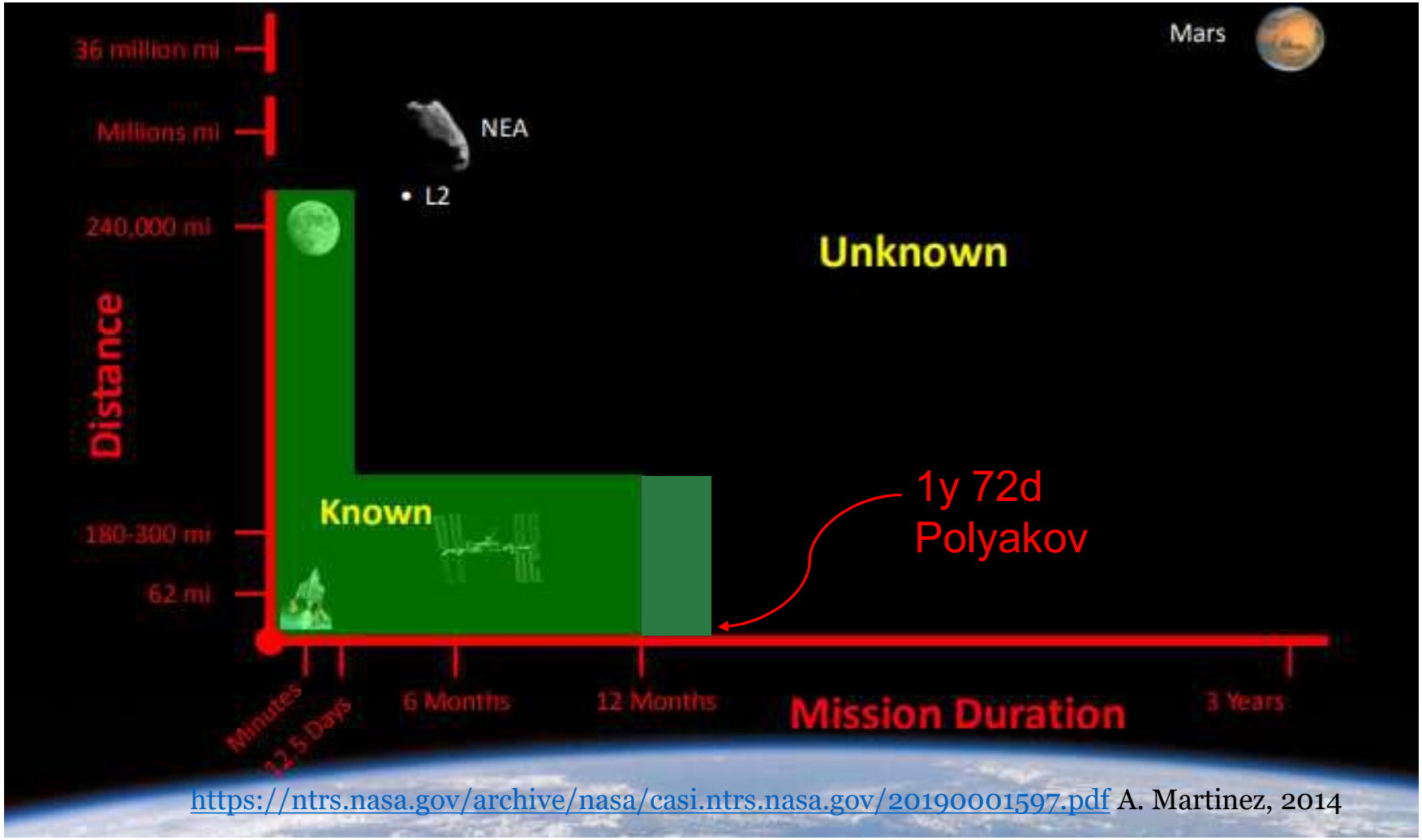
Life (As We Know It) in Space



https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20190001597.pdf A. Martinez, 2014

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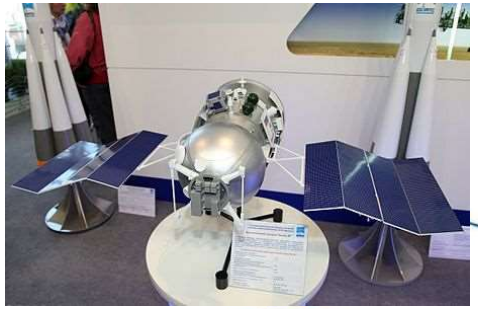
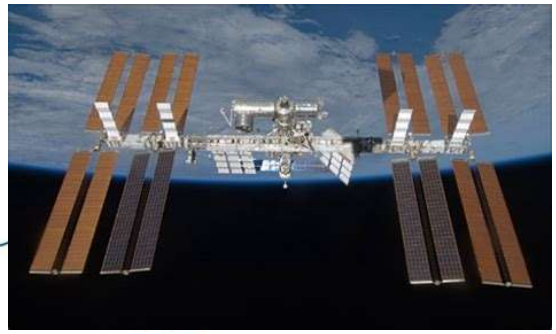
Current Life Sciences Research in Space

Life in Space

Bion- M1



EcAMSat (6U) being deployed from ISS



ISS

Cotton Plants on Chang'e 4

Shenzhou 11 on Tiangong 2

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Future Human Life in Space: Expansion and Extension


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How are we going
to prepare for this?
CubeSats for Biological Research

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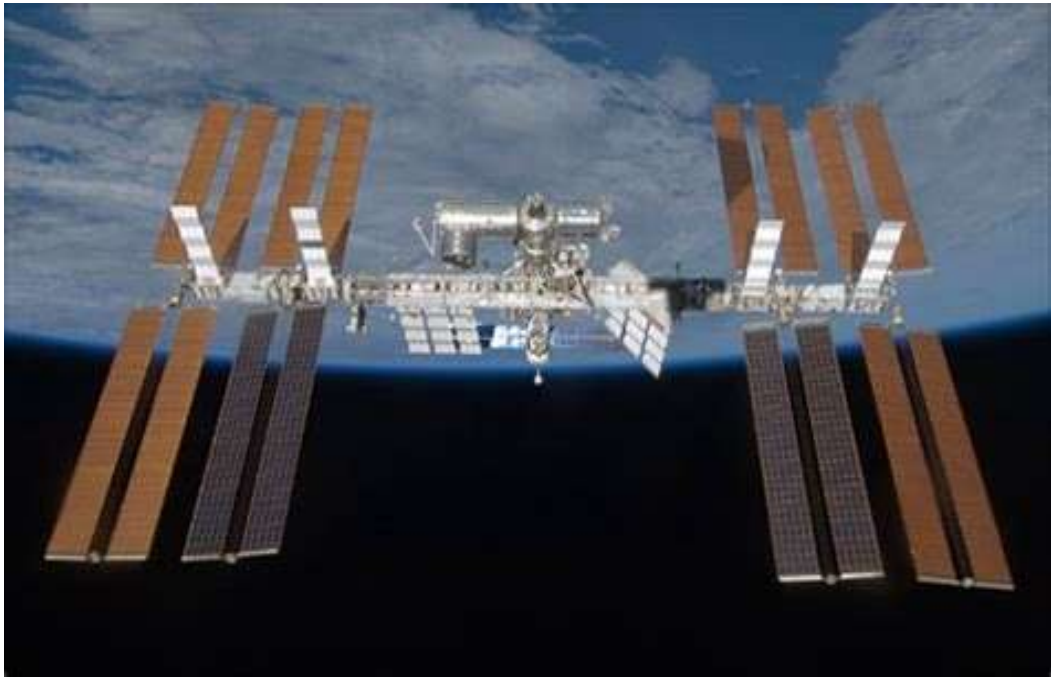
Life Science Research on the ISS



Pros

Long-term studies possible

Access to "large" amounts of power and storage space

Potential for human operation

Potential for small animal (rodent/frog) studies

Cons

Very competitive slots

Expensive + lengthy qualifications campaign

Human involvement is complicated to plan and costly – if it goes right!

May not be environmentally suitable for certain experiments – noise/vibrations leading to “less-than-true” microgravity

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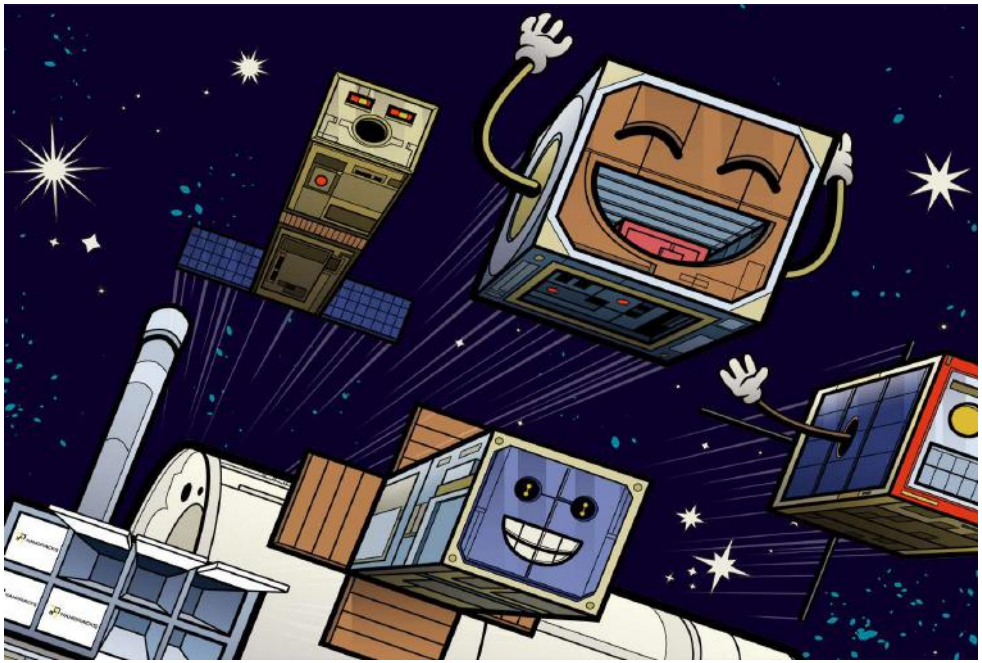
Biomedical CubeSats



Credit: Upward Magazine/ISS National Lab

Pros

Reduced costs allows less wealthy biology labs to specify/develop their own missions

Greater control over the environmental conditions – orbit, radiation, launch time

Short development cycle enables many missions/experiments from same field

Cons

Limited downlink rates

Return of payloads difficult-impossible

Ethics of launching larger organisms/animals

Launch delays post-integration

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NASA Ames' Bio-Cubesats (+SpacePharma DIDO 2)

GeneSat (2006),
3U / E. coli/ Cell growth & Gene Expression measured by light scattering and fluorescence

PharmaSat (2009),
3U / "Brewer's Yeast" / anti-fungal agent efficacy / optical density

O/OREOS (2010),
3U / 2 bacteriae + other biomolecules / different radiation exposures / optical density + fluorescence spectroscopy

SporeSat (2014),
3U / Fern Spores / Lab-on-Chip measured ion concentrations

EcAMSat (2017),
6U / E. coli / anti-biotic efficacy / optical density

BioSentinel (2021)
6U / Artemis-I / "Brewer's Yeast" / deep-space radiation effects / optical density

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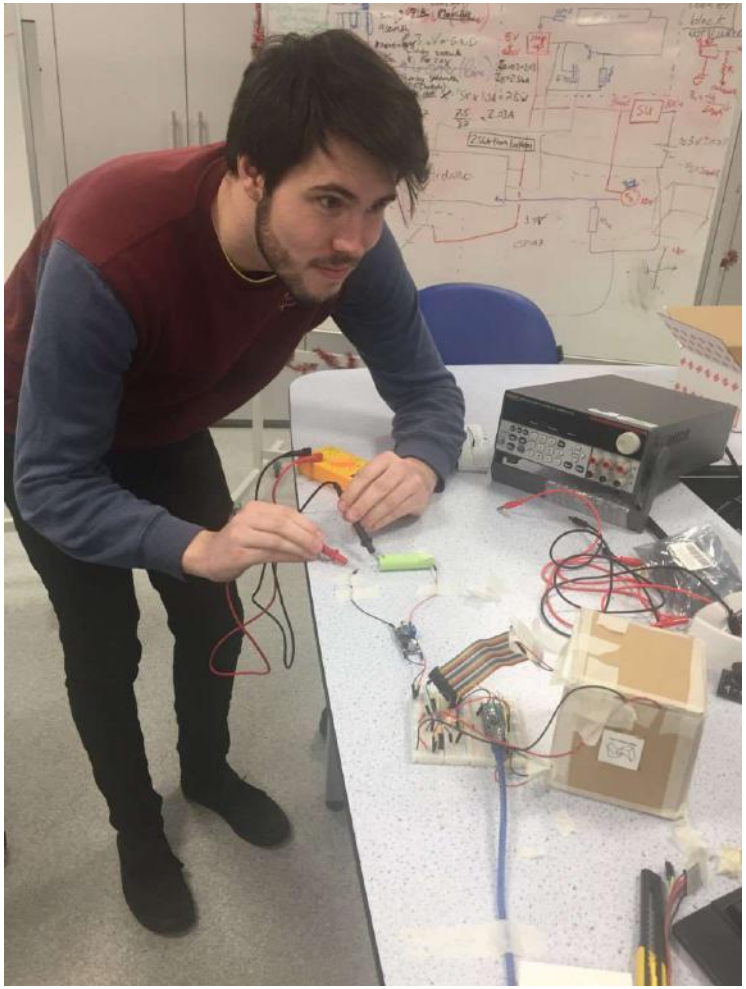
Other Bio-CubeSats (In-Development)

- AstroBio CubeSat
- Cranfield/Exeter - BAMMsat
- KTH Sweden – MIST
- DIDO 3
- GravSat
- Others?...

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Our Platform
University of Nottingham
CubeSats for Biological Research

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UoN Bio-CubeSat Platform Objectives

1.1. To prove the University of Nottingham can develop a platform, capable of supporting biomedical payloads

2.2. To demonstrate the platform is ready to support other biomedical payloads from the University and beyond

3.3. To promote education and cooperation between faculties and staff/students involved in the project

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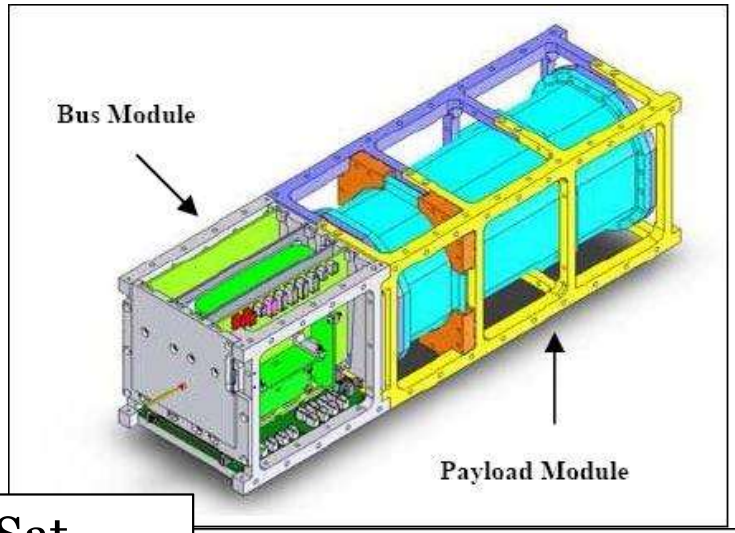
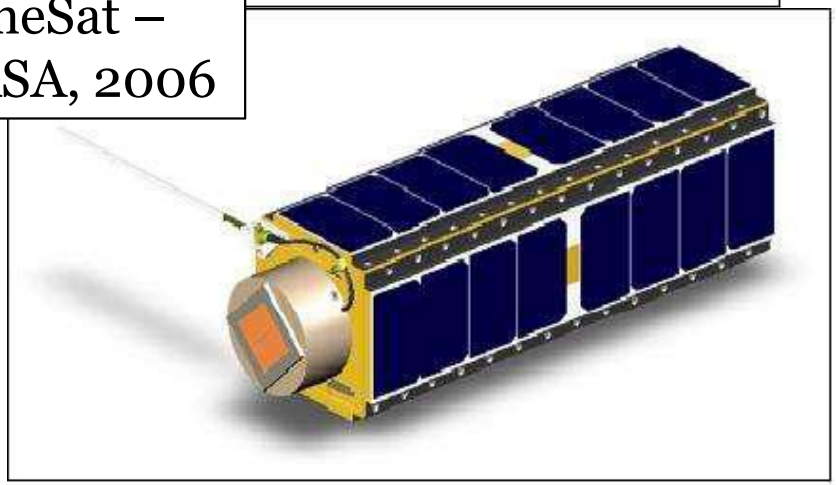
University of Nottingham Bio-CubeSat



GeneSat – NASA, 2006



- 3U form factor
- ~2U of Payload enclosed in a pressurised, thermally controlled environment (flight heritage in NASA's PharmaSat, GeneSat…)
- Short optical-depth, optical microscope, radiation measurements from scintillator instrument
- Photos (or videos) taken regularly throughout flight to prove Payload Culture's survival
- **Photos** transmitted along with **flight housekeeping** and **environmental** sensors' data

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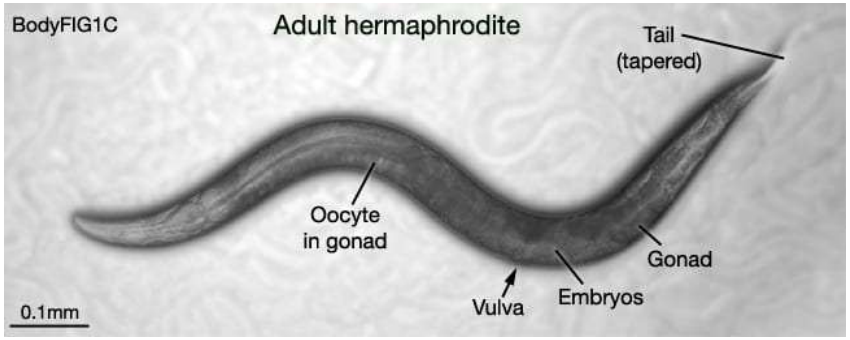
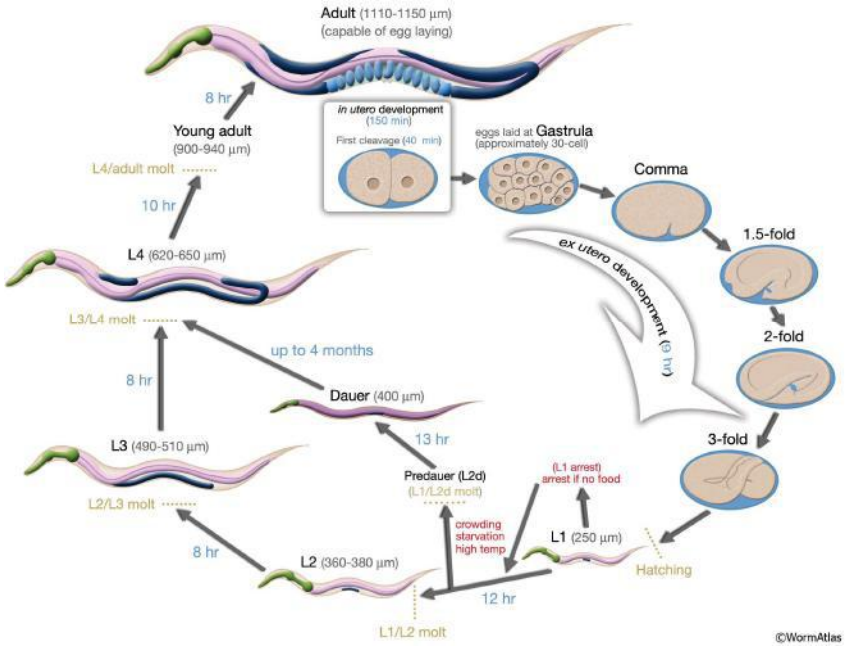
"Model" Astronauts





- ***Caenorhabitditis elegans***
- Model organism used extensively in ground and space research – ageing, genetics, muscle physiology…
- Adults are ~1mm in size
- Very resilient: typically lab grown at 15 – 25°C
- Rapid life cycle: egg-> egg-laying adult in 2-4 days, death ~10-20 days)
- Dauer stage enables survival for 6-months

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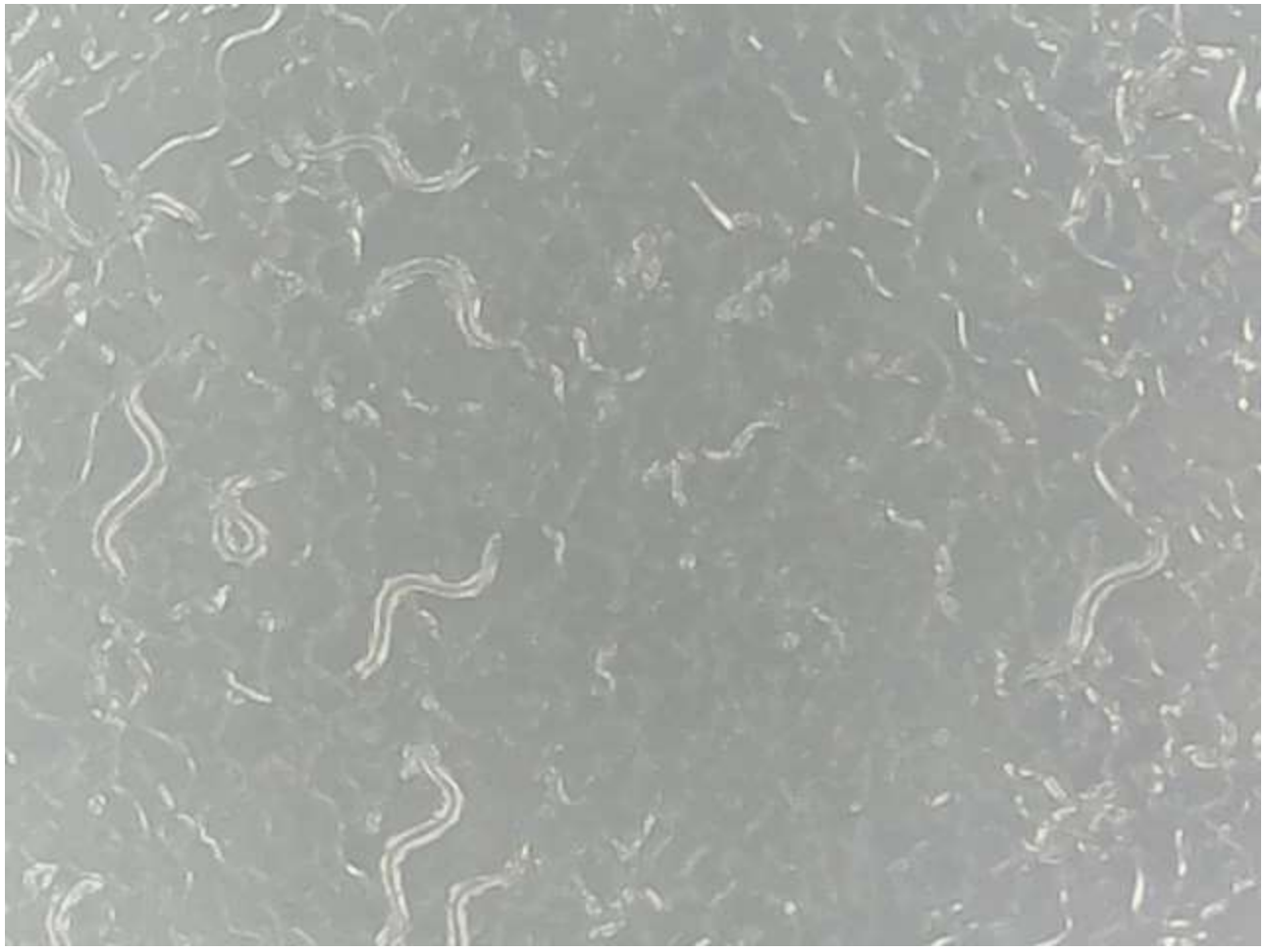
"Model" Astronauts



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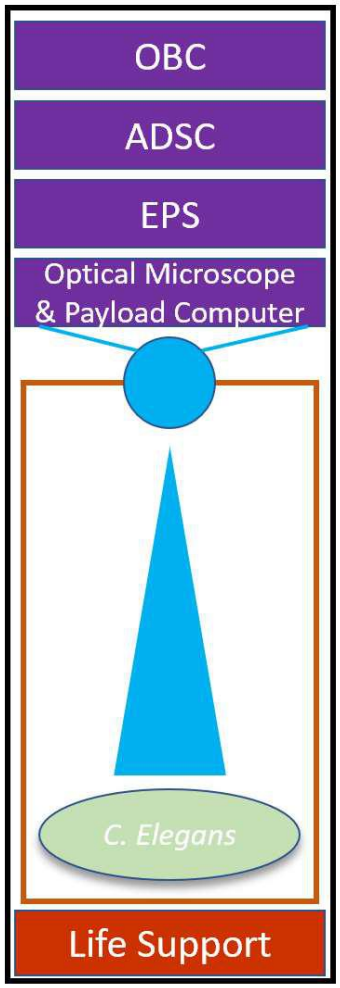
University of Nottingham Bio-CubeSat



- *How to keep colony alive while on the launchpad?*
- C. elegans integrated before launch in "Dauer" state – deprived of food + temperature dependent
- Once orbital communications established with CubeSat, food solution released to culture using micro-fluidics
- Colony grows as normal and monitored with microscope

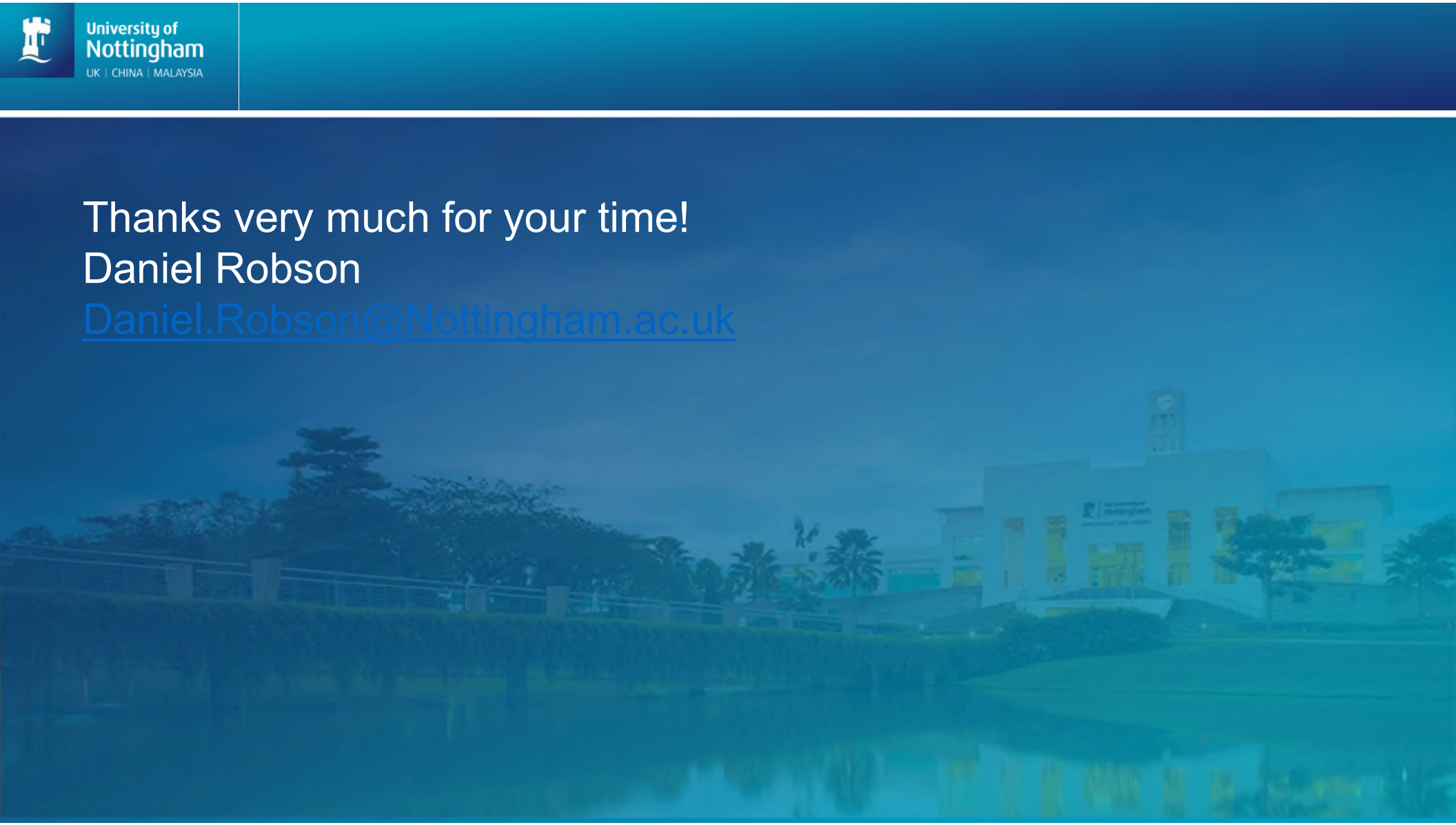
- *…Results compared to lab control cultures*
- *Comparative Measurements can be made of population growth and/or movement speed*

Conclusions

- There is a human **need** for **cheaper access** to space as a **biology laboratory.** Both for space exploration and improving the quality of life on Earth.

- CubeSats are likely (and already are) to be utilised to fulfil the role of a platform to support this.

- *C. elegans* are to be launched as they are: a **model organism, robust** and can be **"persevered"** before launch.



Thanks very much for your time!

Daniel Robson

Daniel.Robson@Nottingham.ac.uk