Challenges for future Space exploration...

- As humans begin to explore greater distances in Space there is a need to develop life support systems that meet all their basic needs in terms of nutrition, water, oxygen, and waste disposal.

- The ESA MELiSSA closed-loop is a series of inter-connected compartments that aims to be a solution to this problem1 (Figure 1).

- The food produced in compartment IV needs to meet all the dietary requirements of the astronauts, from proteins to vitamins.

How can microalgae help provide B12 on Earth and potentially in Space?

- Vitamin B12 is a tetrapyrrole with a cobalt ion at the centre, synthesised by prokaryotes, its lower and upper axial ligands can vary changing its bioavailability to humans2.

- Many eukaryotic algae, like humans, are B12 dependent3 and have been shown to obtain B12 from bacteria while in coculture, in exchange for fixed carbon4. Therefore, could algae be used to accumulate B12, and then consumed to meet humans’ recommended daily allowance?

Aims to investigate vitamins and mutualisms...

1. Develop mutualisms between bacteria and algae involving B12, using species generally recognised as safe for human consumption (GRAS) such as Arthrospira plantensis, Haematococcus pluvialis and Chlorella vulgaris.

2. Use the most promising mutualisms to investigate how they could be used in the MELiSSA closed-loop system for the provision of B12 to astronauts on long Space missions and on Earth.

**Arthrospira plantensis**

- As a cyanobacterium it produces the less bioavailable form of B12, pseudocobalamin5. Some algae can remodel this to cobalamin if provided with 5,6-dimethylbenzimidazole (DMB)6. Can A. plantensis also do this?

- Can A. plantensis accumulate cobalamin when grown in coculture with bacteria7, synthesising bacteria?

**Chlorella vulgaris and Haematococcus pluvialis**

- Given the different cellular morphologies of the species and differences in lifecycle is there a difference in B12 uptake and their interaction with bacteria8?

- How do any mutualisms compare to the previously studied systems?

**MELiSSA focused aspects**

- How does microgravity effect the mutualism?

- Can cobalt be recycled from the system as part of the closed-loop design?

Results

- Both C. vulgaris and H. pluvialis are B12 independent, and can accumulate it when added externally (Figure 2), although H. pluvialis to a lesser extent even after 24 hours (Figure 3).

Next steps...

- Identify suitable bacterial producers of bioavailable B12 that could be used in coculture with the algae. For example, the MELISSA organism *Rhodospirillum rubrum* has the necessary genes for B12 biosynthesis, and this has been experimentally verified9.

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References