UNIVERSITY OF CAMBRIDGE

Department of Plant Sciences

Algal Biotechnology
Antarctic snow algae blooms

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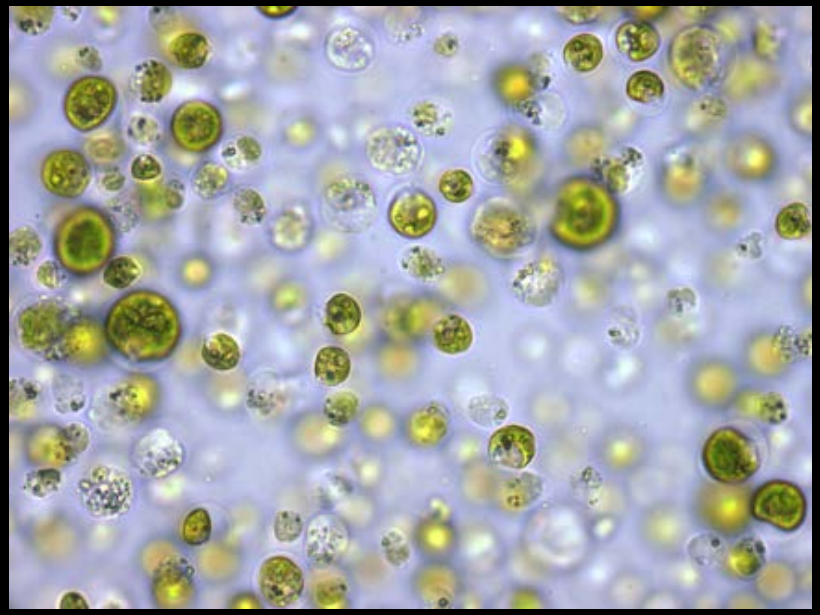
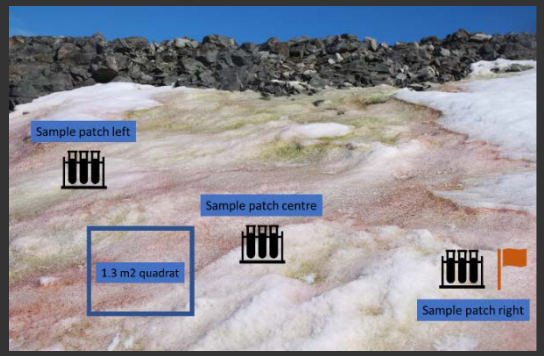
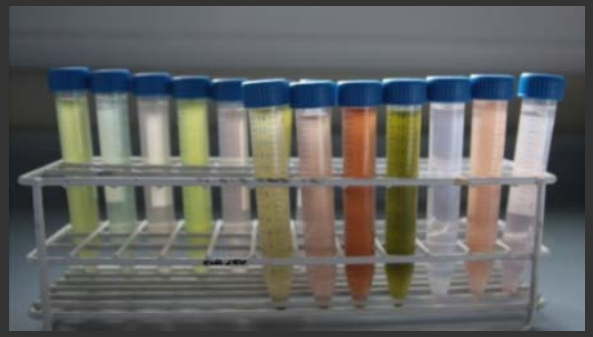
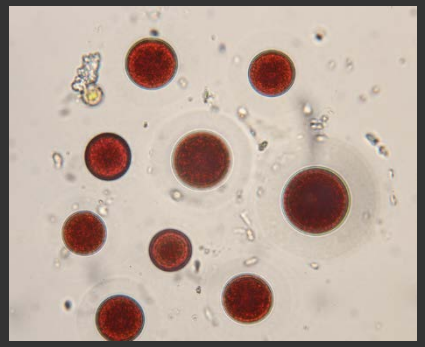


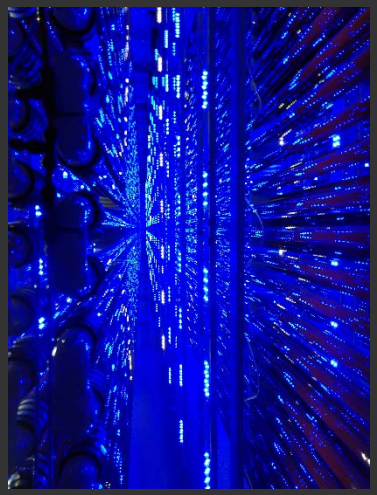
What are algae?

What is algal biotechnology?









Study and manipulation of algal physiology and ecology for innovative purposes…

What is algal biotechnology?

Advances in high volume, low value products

Bioenergy
- Lipids (TAGs) for biodiesel
- Hydrocarbons, fatty alcohols, isoprenoids
- Bio-ethanol
- Bio-hydrogen
- Anaerobic digestion

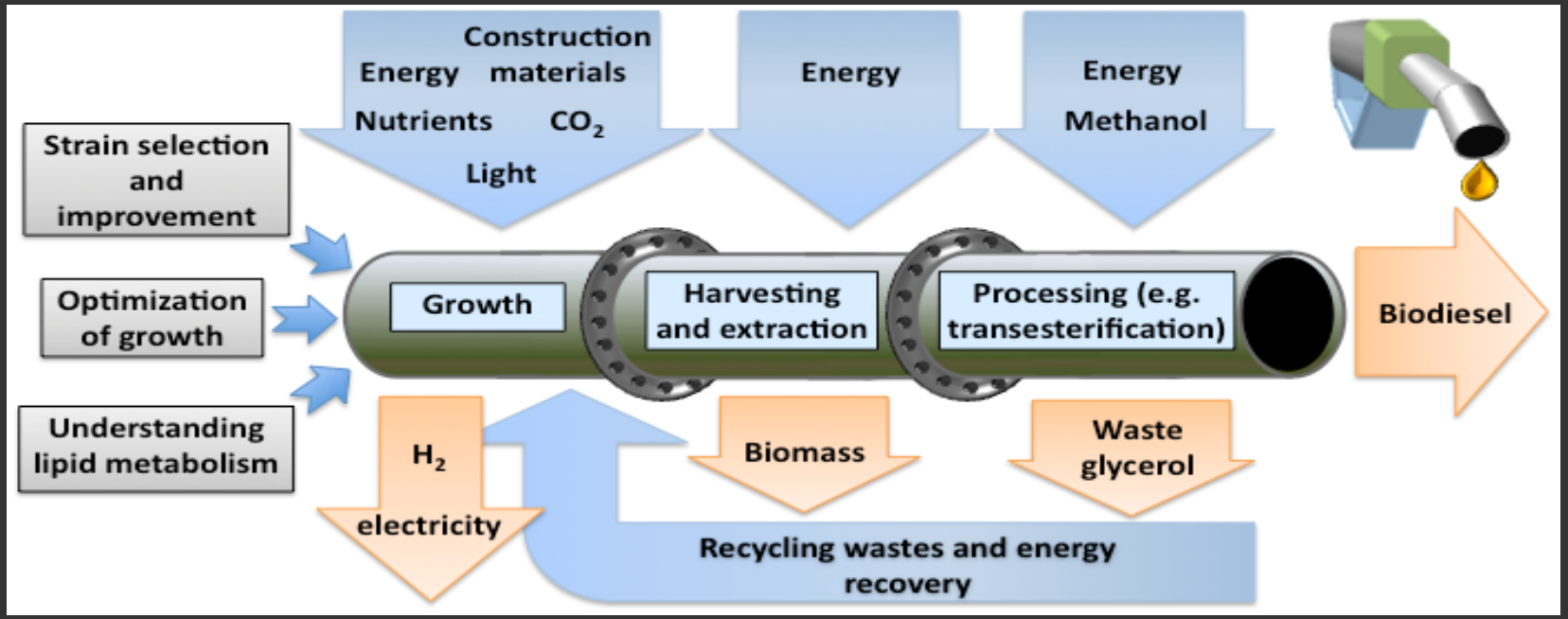
Remediation and biomass
- CO_2 conversion into biomass
- Bioremediation of wastewater (removal of N, P, heavy metals)
- Soil improvers
- High protein feed for livestock or aquaculture

Nutraceuticals, food additives, cosmetics, materials
- Vitamins – provitamin A
- PUFAs – EPA/EHA
- Antioxidants – astaxanthin
- Pigments – lutein, phycocyanin

Pharmaceutical products
- Novel proteins
- Vitamins
- Vaccines
- Protein antibiotics
- Antibodies

Advances in low volume, high value products

Bottlenecks remain in algal pipeline

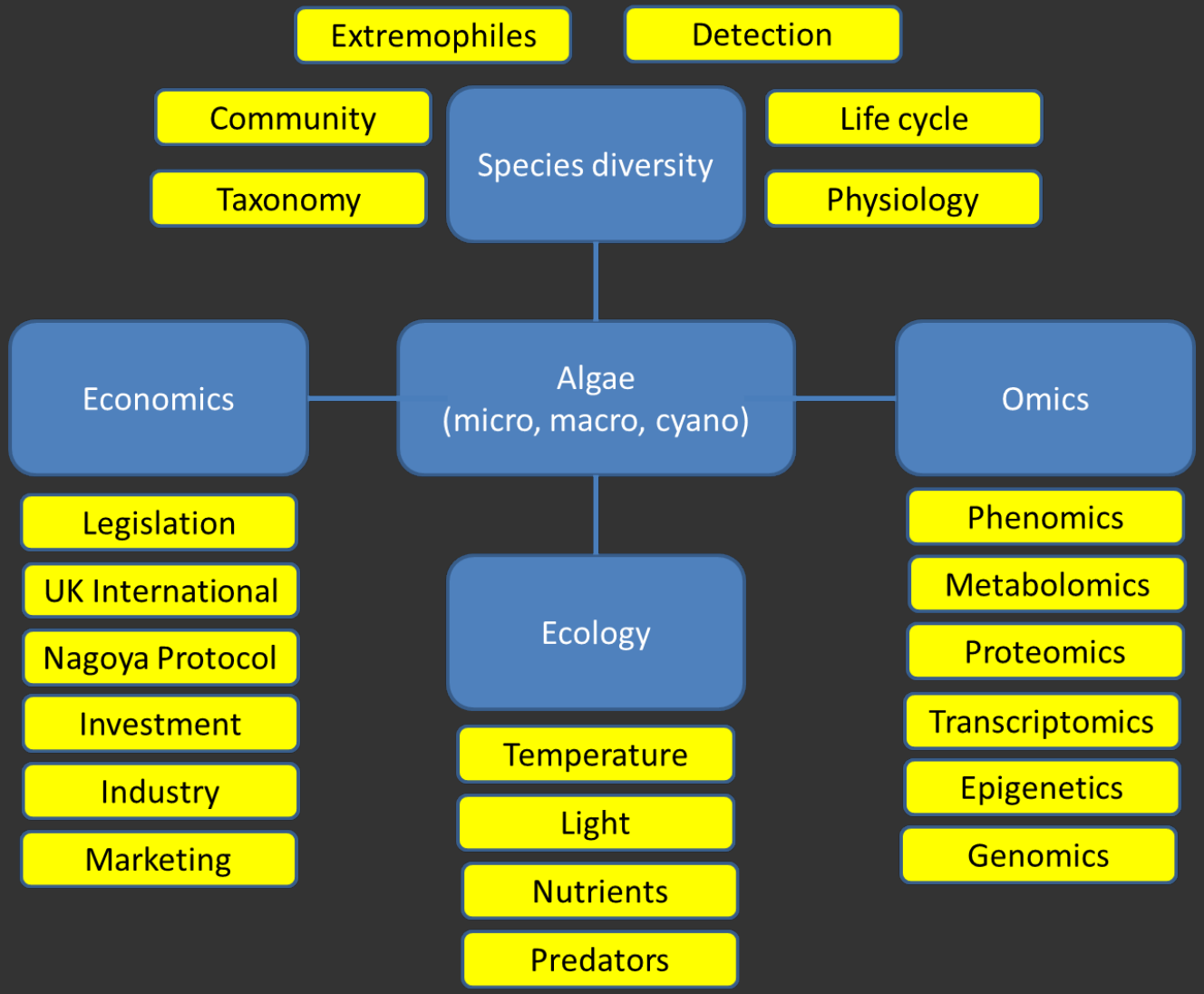


Industry need biomass
Limited range of species for human consumption
Genomic tools limited to few species
Skills base/education

Metabolic diversity largely unknown
Scale-up challenges
Legislation
Ultimate price

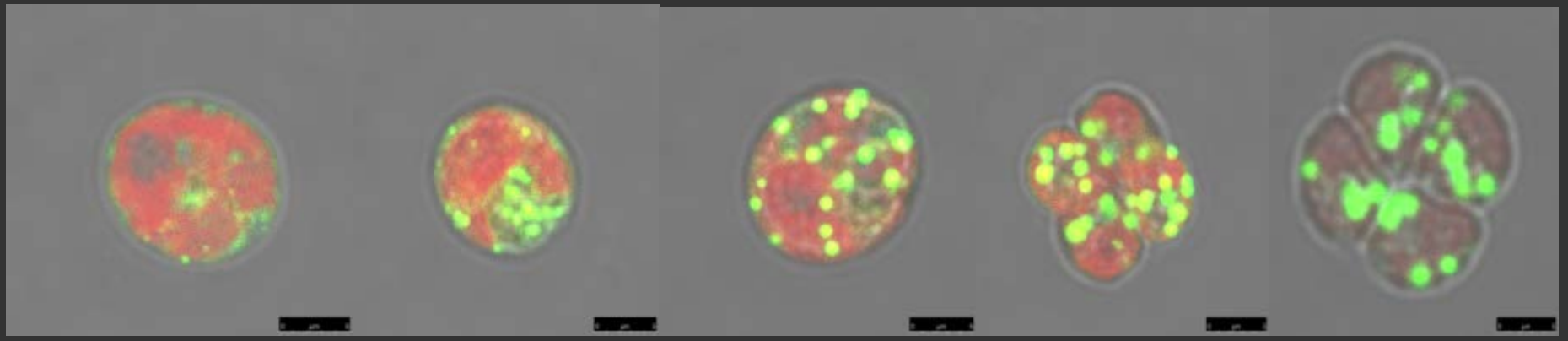
Scott et al. (2010) Curr Op Biotechnol.

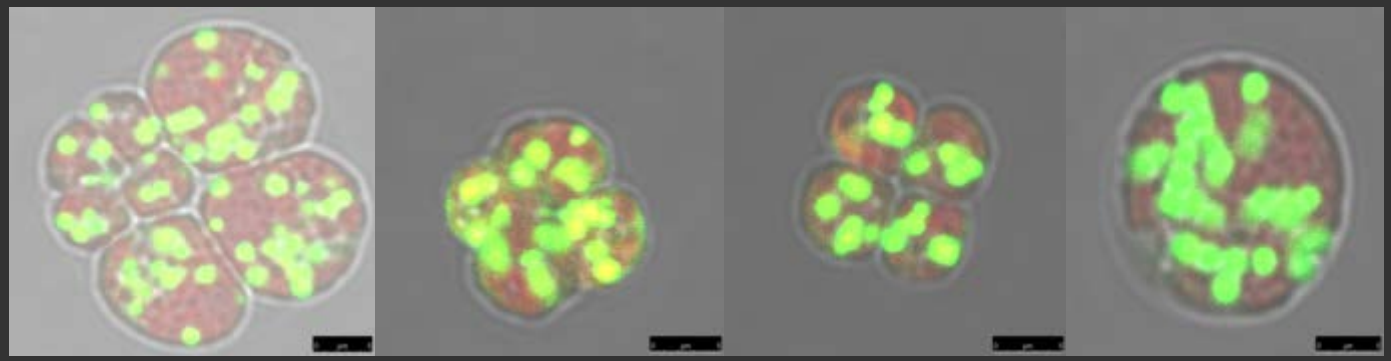
Tools and factors to help solve bottlenecks



Things lab 220 and I are interested in…

Algal Oils – changing environment can alter which biochemical are made, or degraded in the cells

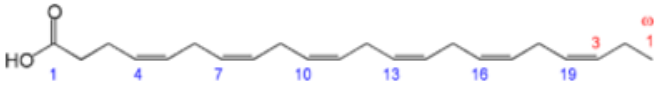




Yellow = lipid (nile red)
Red = chlorophyll
Confocal Fluorescence

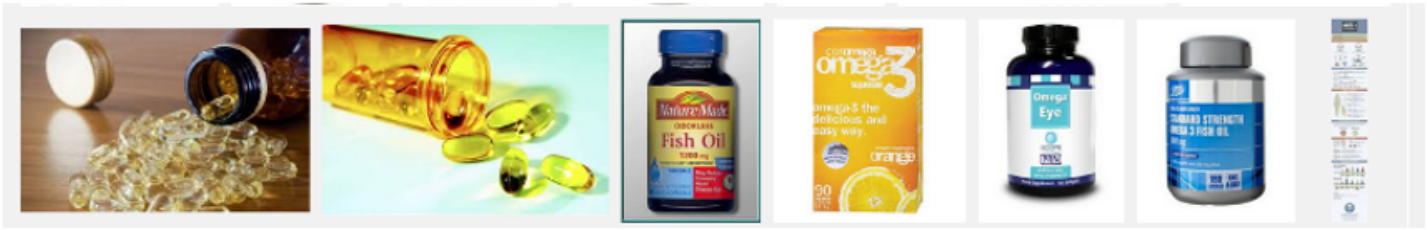
Induction of TAG accumulation over time in *Chlamydomonas* (wild type) by reducing the N concentration in the growth media

Food ingredients of interest – sustainable sourcing

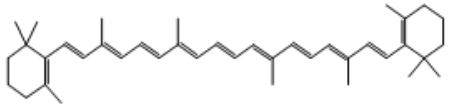


Omega-3 docosahexaenoic acid (DHA).

Omega-3 eicosapentaenoic acid (EPA).



β-carotene



Vitamins

Starches

Astaxanthin

Polyhydric alcohols (sorbitol, mannitol)

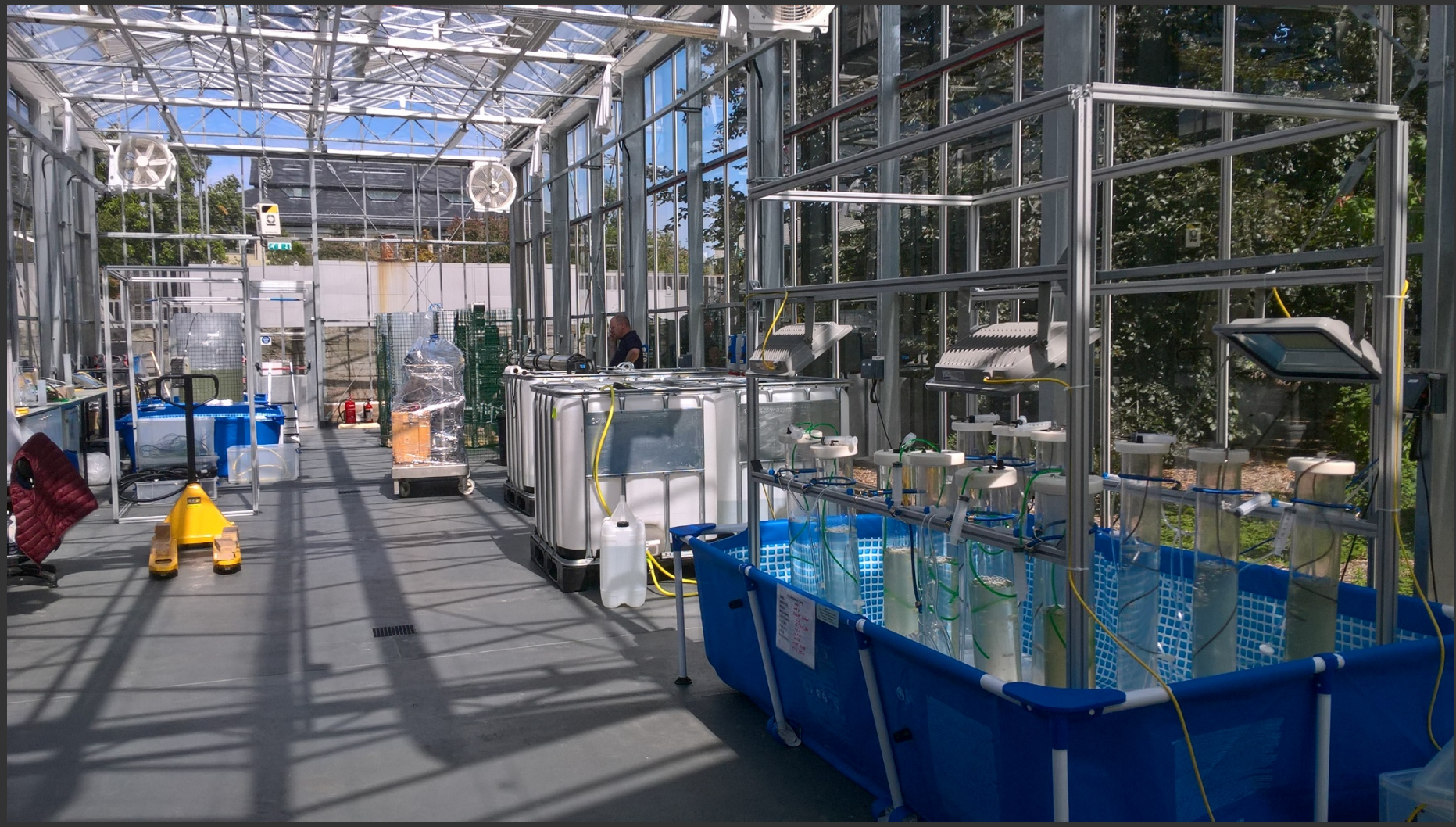
Palmitic acid – palm oil replacements

Algal Innovation Centre in Cambridge

Natural light and heating

GM grade glasshouse, sealed floor, kill tanks, lab benches

Algal Innovation Centre in Cambridge

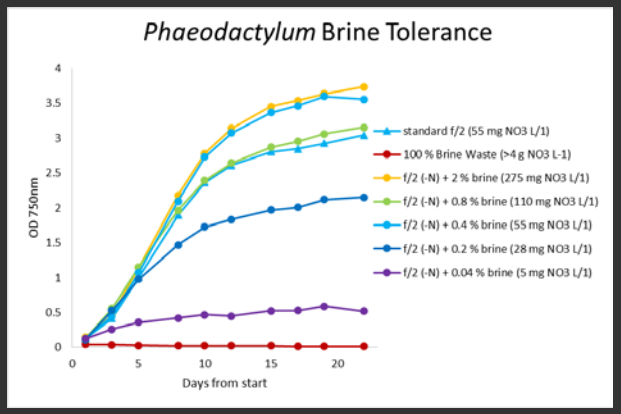


Payam Mehrshahi and Lorraine Archer – Lab 220

Drinking Water Innovation - Bioremediation of Brine Wash using Microalgae

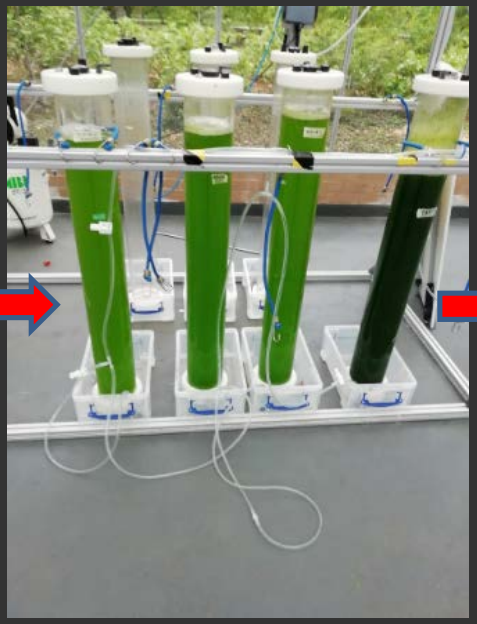
CAMBRIDGE WATER COMPANY

Waste Water
Nitrate/Nutrient Rich Waste



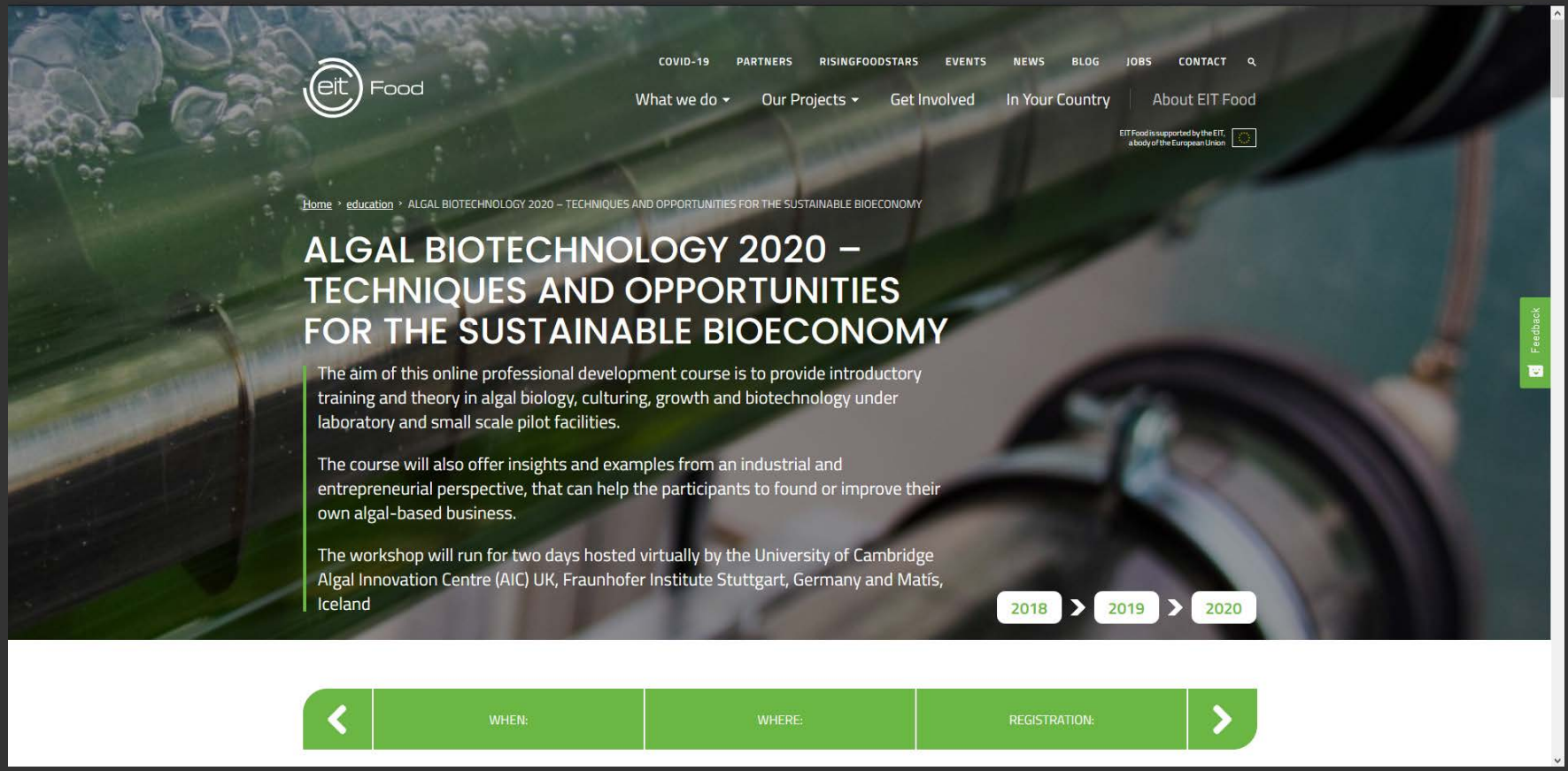
Anaerobic Digestion
Electricity Production
Extra ‘Green’ Revenue

Many different industry and academic projects on algal biotechnology
Policy – GMO safety – Environmental Risk Assessments



AgriGrub

Education and training



19th and 20th November 2020

https://www.eitfood.eu/education/projects/algal-biotechnology-techniques-and-opportunities-for-the-sustainable-bioeconomy-2020

Sustainable natural production of vitamins for human consumption in long space missions using synthetic ecology approaches

Can algae and bacteria produce enough vitamins for long space trips?

Ellen Harrison, Alison Smith, Payam Mehrshahi, Natalie Leys

Polar algae – exploiting cold tolerant phenotypes in polar diatoms for increased growth and metabolite production – NERC DTP PhD

- growth and metabolic characteristics of polar diatoms and screen metabolites for novel properties
- intraspecific variation of genetic and metabolic characteristics between temperate and polar strains of diatom species

Sam Coffin (PhD student)

Prof Melody Clark (BAS), Prof Alison Smith, Dr Matt Davey

Department of Plant Sciences

NERC Science of the Environment

British Antarctic Survey
Natural Environment Research Council

University of Cambridge

Algal Biotechnology

- What is Algal Biotechnology?
- Algae in the food sector
- Snow algae and climate change

Snow algae blooms (10's to 100's m^2)

Snow algae – first large scale map of blooms in Antarctica

nature COMMUNICATIONS

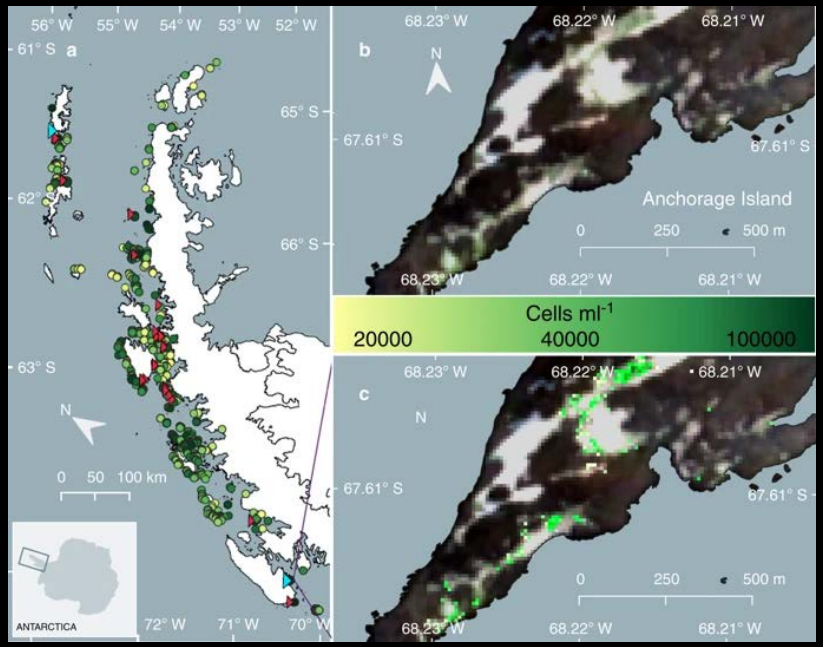
ARTICLE

Check for updates

https://doi.org/10.1038/s41467-020-16018-w OPEN

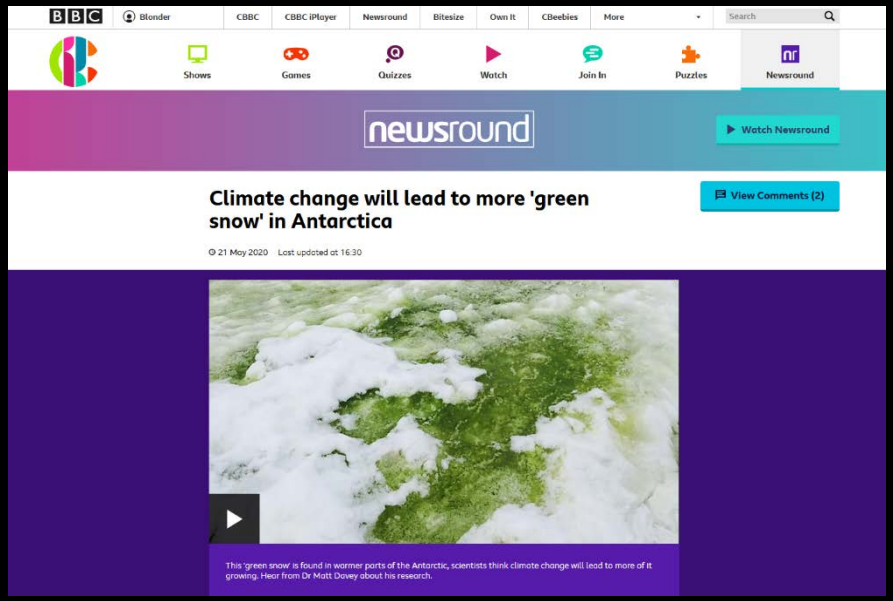
Remote sensing reveals Antarctic green snow algae as important terrestrial carbon sink

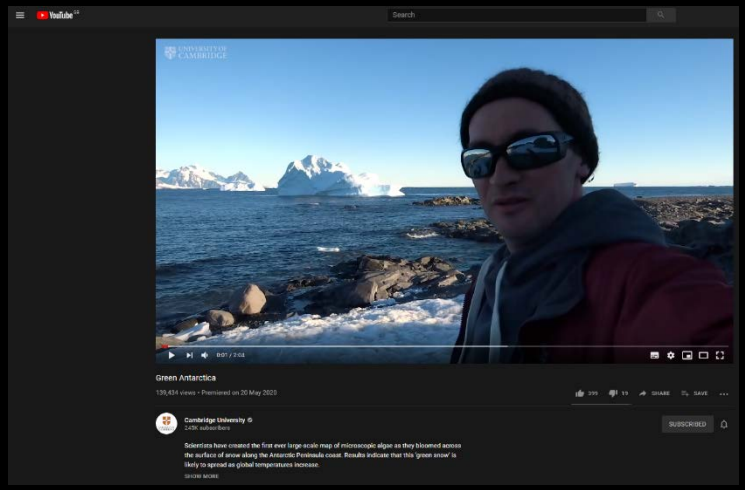
Andrew Gray[1,2✉], Monika Krolikowski[1], Peter Fretwell[3], Peter Convey[3], Lloyd S. Peck[3], Monika Mendelova[4], Alison G. Smith[1] & Matthew P. Davey[1✉]

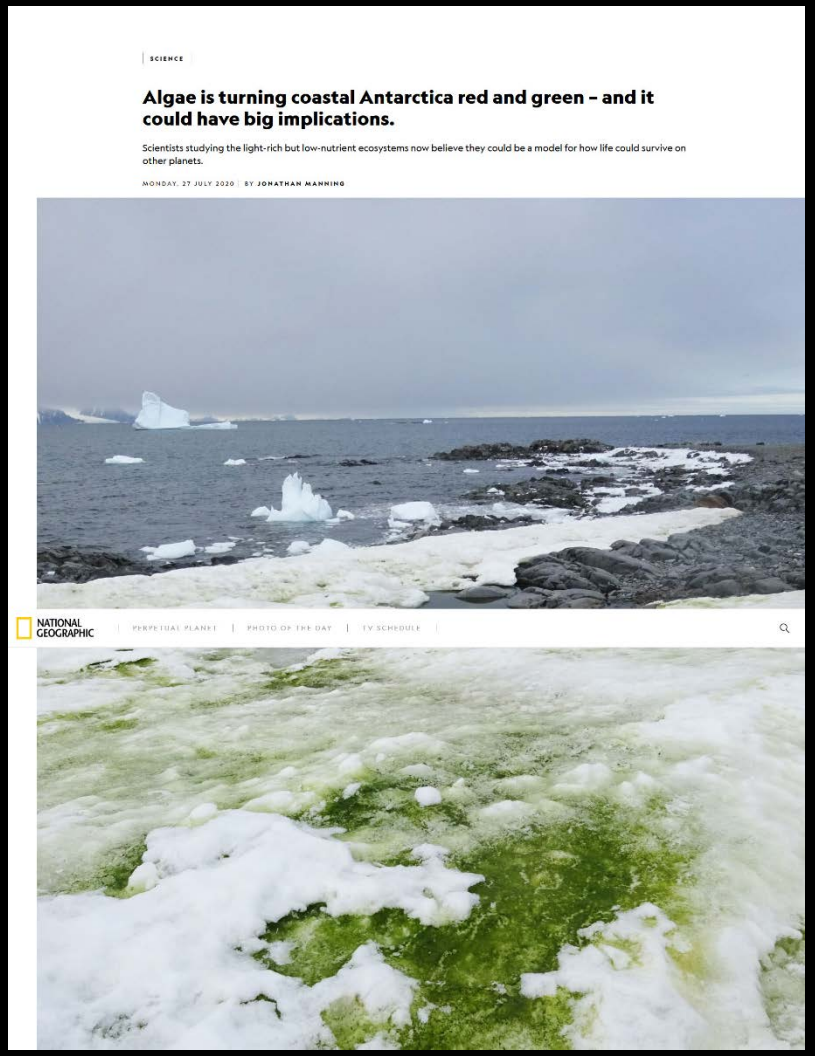


Snow algae – first large scale map of blooms in Antarctica

Gray et al Nature Comms 2020

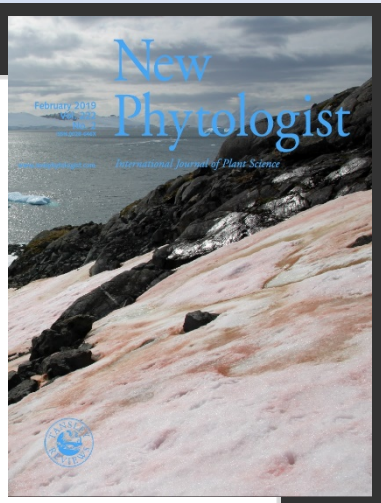


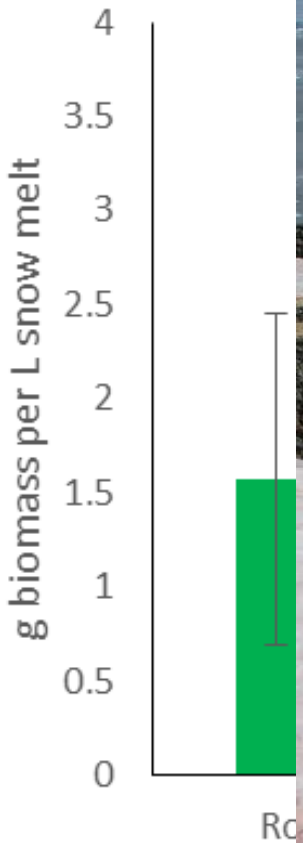


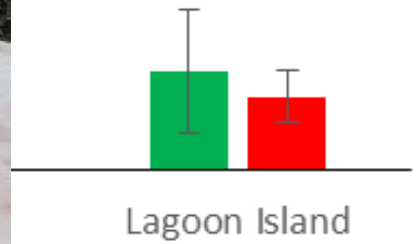


Over 1.7 billion reach on media
(Ucam and BAS metrics)

Dry biomass in snow melt – high biomass in green phase (landscape level contribution)

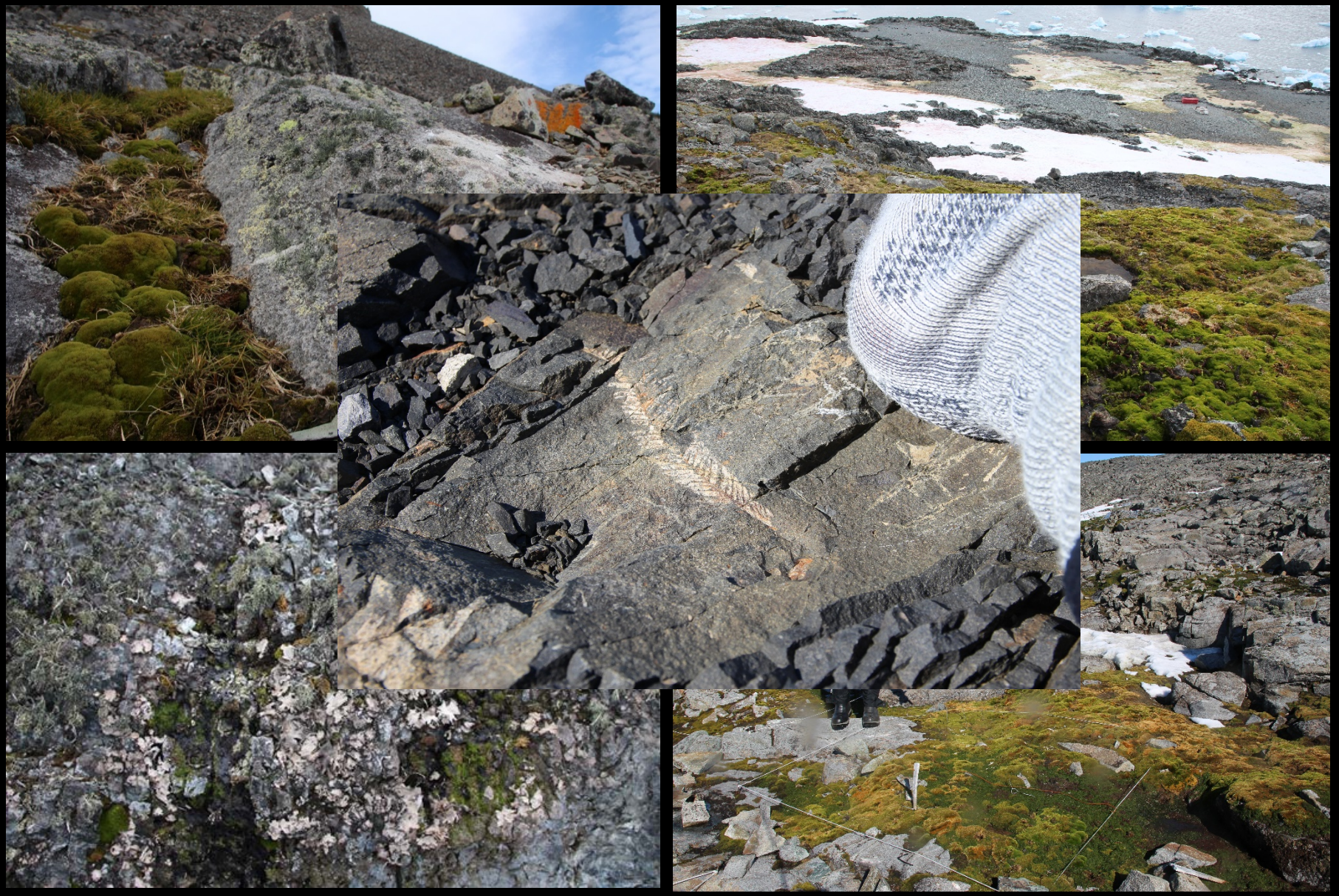






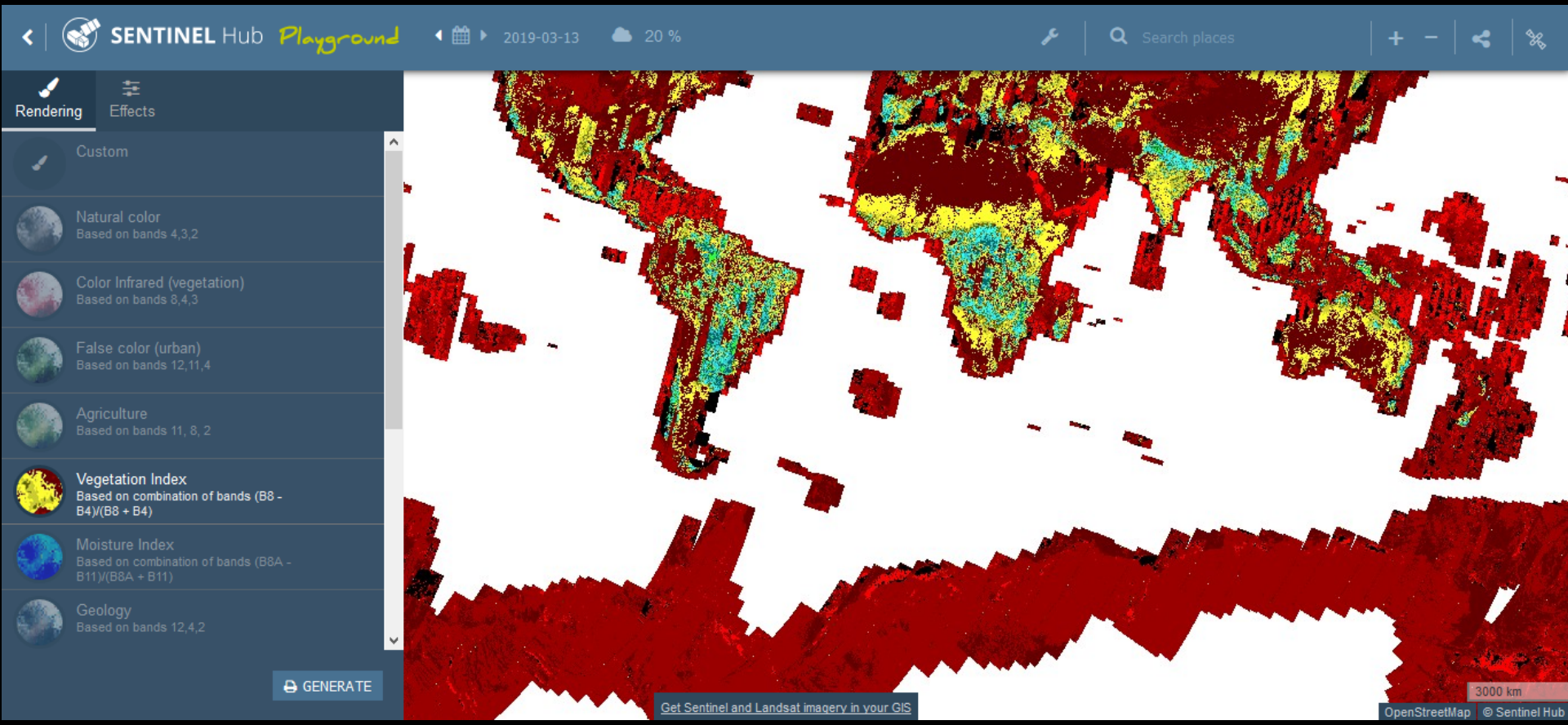
3 g m²

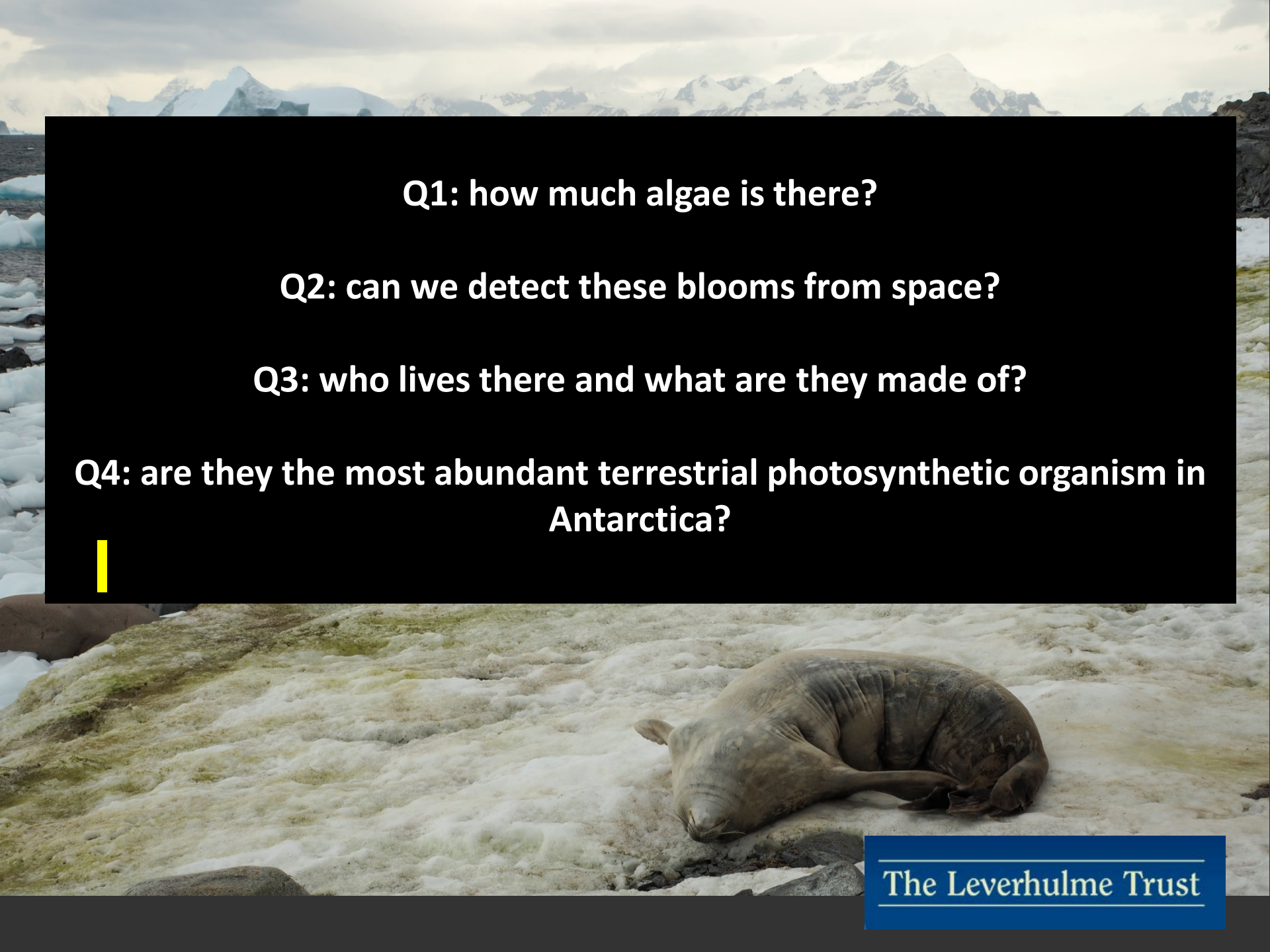
Compared to mosses, lichens, grasses, liverworts?



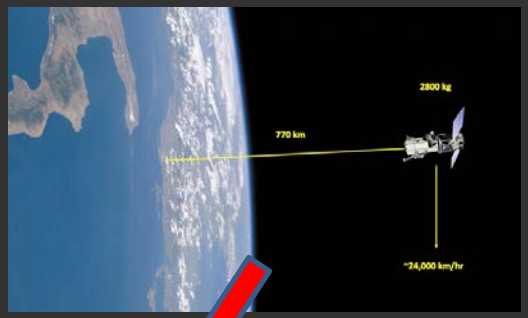
Deschampsia antarctica, Xanthoria elegans, Usnea antarctica, Umbilicaria decussata, Andreaea regularis, Stef Bokhorst

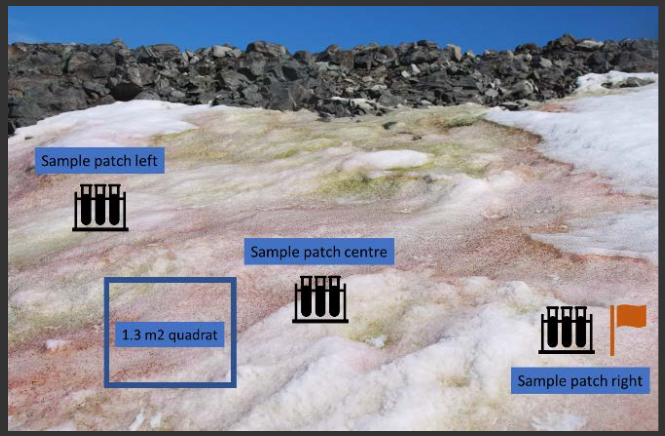
SENTINEL Hub Playground – Vegetation Index

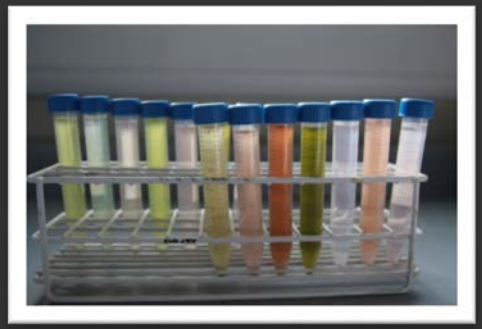



Q1: how much algae is there?
Q2: can we detect these blooms from space?
Q3: who lives there and what are they made of?
Q4: are they the most abundant terrestrial photosynthetic organism in Antarctica?
The Leverhulme Trust

Data collection 2015, 2018, 2019







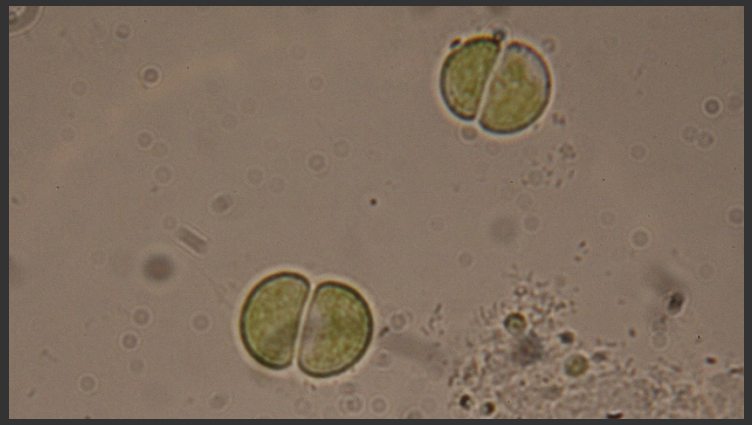
Biological sampling (KGI – north end)

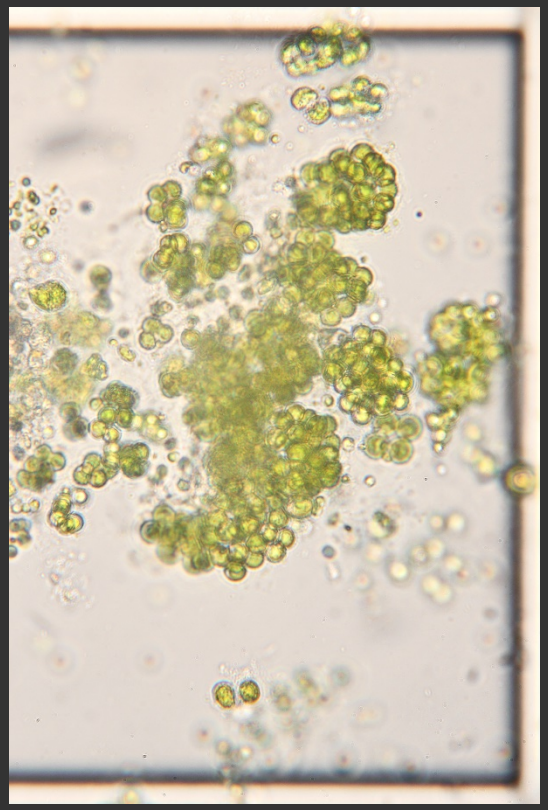
Ryder Bay, Antarctica (South end) (2015/2018)

Light: 500 to 2000 PAR; *Temperature: -4 °C to +5 °C*

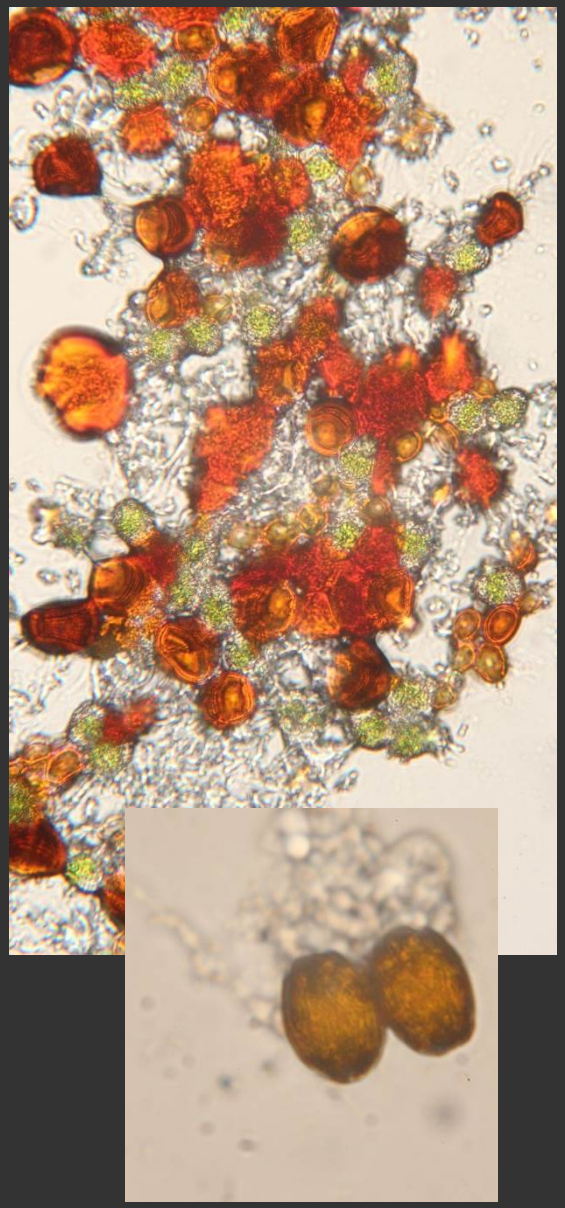
Mainly green, then red later in season (layer ~22mm thick)

Green community diversity (Ryder Bay 2018)

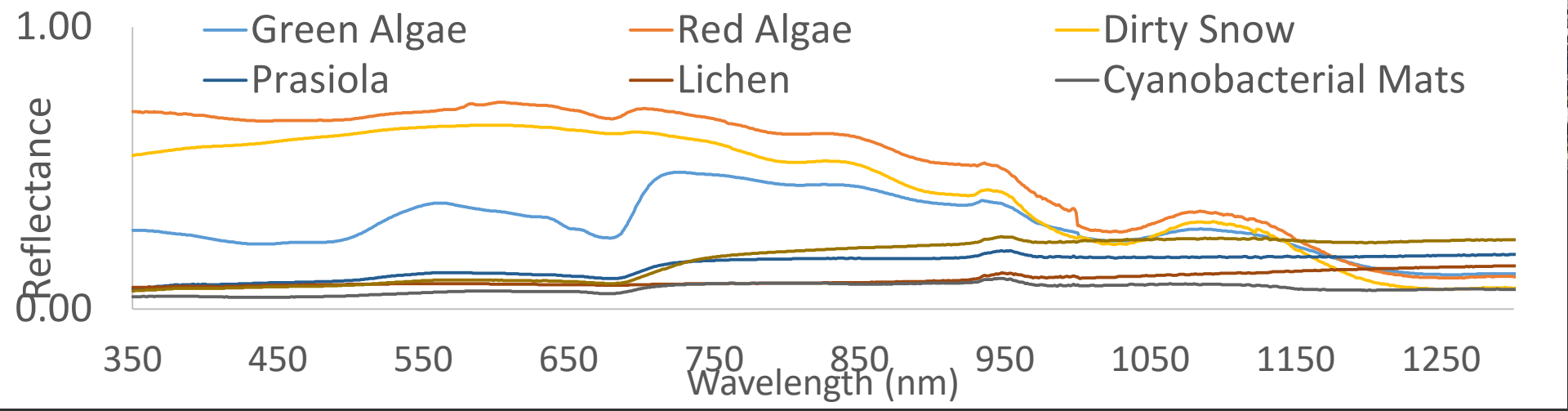




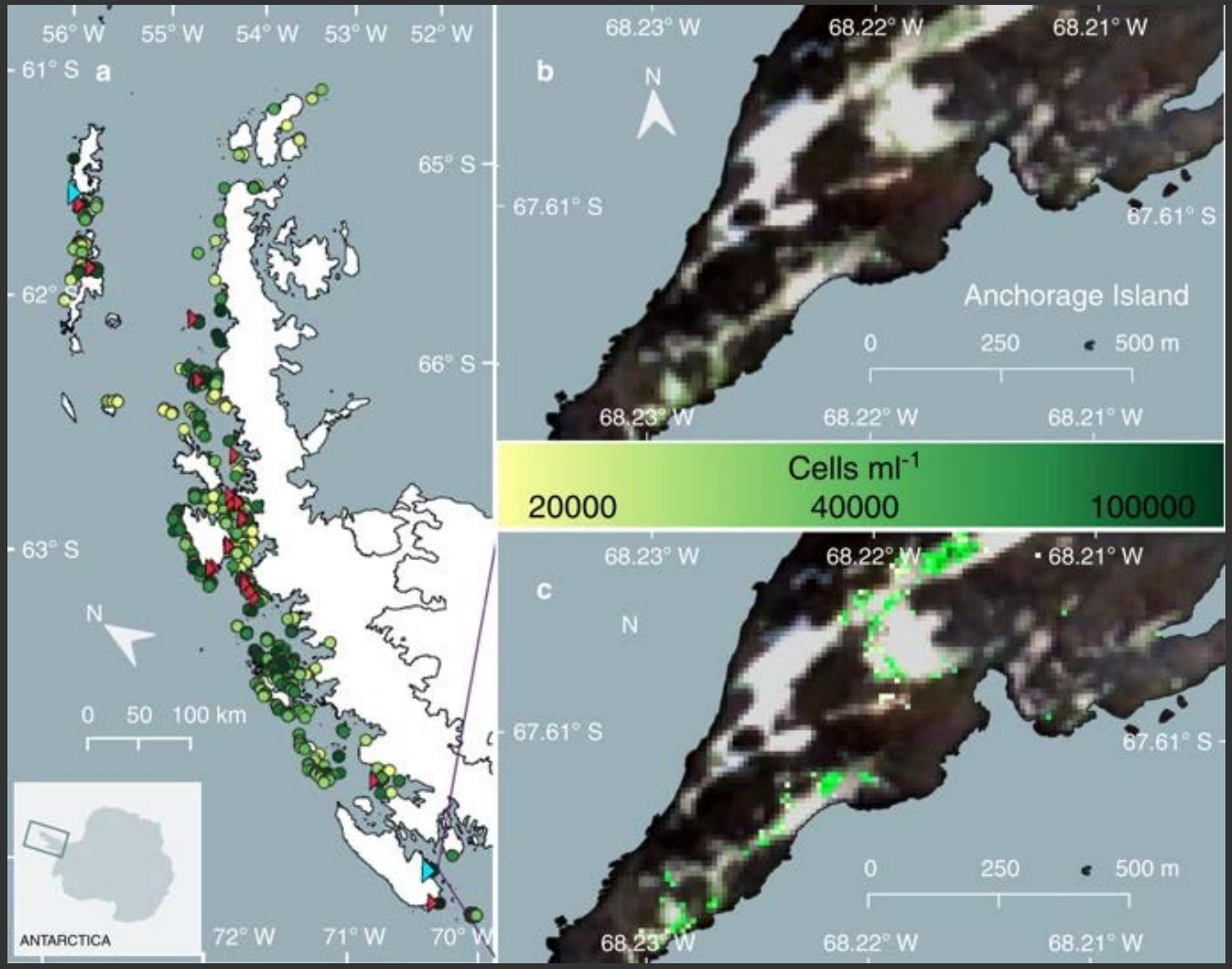
Red community diversity (Ryder Bay 2018)



A spectral library of Antarctic vegetation



Gray et al Nature Comms 2020



New Nature Comms paper data and images…

Combination of empirical data from field measurements and satellite imagery from 2017-2019

1679 green blooms identified

At least 1300 tonnes of green snow algae

Covering 1.95 km^2

Equating to approximately 479 tonnes of carbon

About 60% of blooms were within 5 km of a penguin colony

New Nature Comms paper data and images…

A warming Antarctica may lose a majority of the 62% of blooms occupying **small**, low-lying islands with no high ground for range expansion

But **bigger** blooms at higher elevation may increase, if close to bird or seal colonies

Increase predicted to outweigh biomass lost from small islands

Resulting in a net increase in snow algae extent and biomass as the Peninsula warms

Thank you!


INACH


ROYAL NAVY
HOMEWARD BOUND.


esa


AIRBUS
DEFENCE & SPACE


The Leverhulme Trust


planet.


British
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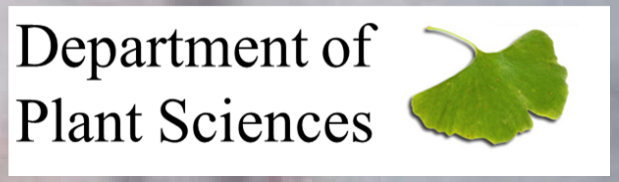
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Questions!