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UNIVERSITY OF  
CAMBRIDGE

# Algae: Food for the Future Kitchen

# Algae: Food for the Future



Challenges for future food



What are algae?



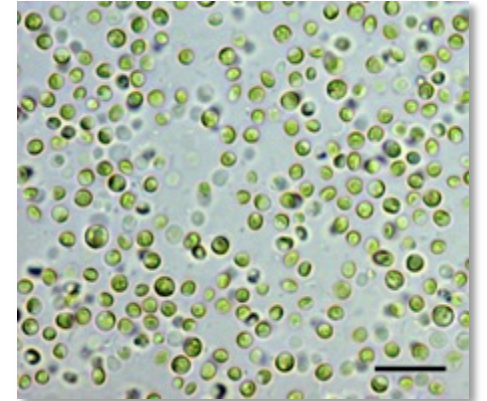
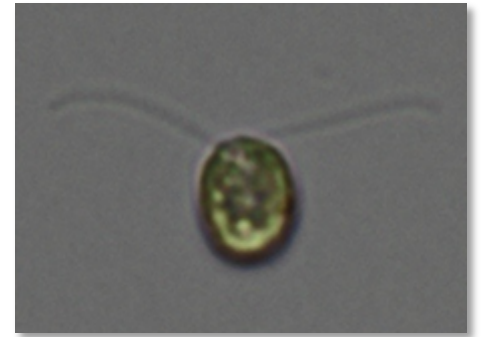
Algae for food and feed

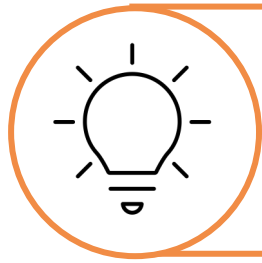


Cultivating algae at scale



Algae for a more circular future





# Challenges for future food



NO  
POVERTY



ZERO  
HUNGER



GOOD HEALTH  
AND WELL-BEING



QUALITY  
EDUCATION



GENDER  
EQUALITY



CLEAN WATER  
AND SANITATION



AFFORDABLE AND  
CLEAN ENERGY



DECENT WORK AND  
ECONOMIC GROWTH



INDUSTRY, INNOVATION  
AND INFRASTRUCTURE



REDUCED  
INEQUALITIES



SUSTAINABLE CITIES  
AND COMMUNITIES



RESPONSIBLE  
CONSUMPTION  
AND PRODUCTION



CLIMATE  
ACTION



LIFE  
BELOW WATER



LIFE  
ON LAND



PEACE, JUSTICE AND  
STRONG INSTITUTIONS



PARTNERSHIPS  
FOR THE GOALS



# What are algae?

- Incredibly diverse
- Conservative estimates suggests there are over **70, 000 species** of microalgae (Guiry, 2012)
- **Less than 50** currently used for commercial purposes (EABA, 2020)





# Features of algae for food and feed



- High protein – balanced amino profile
- Essential fatty acids – omega-3s
- Many algae classified as GRAS – generally regarded as safe
- High vitamin and mineral content

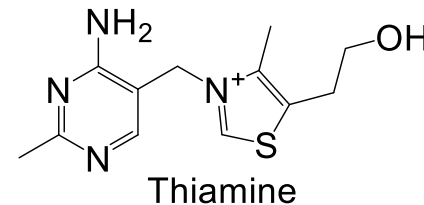


# What are “Vitamins” in organisms?



- Organic micronutrients that are required for growth

- Originally coined for ‘vital amine’, thiamine,
- Isolated from rice husks and cures beri-beri

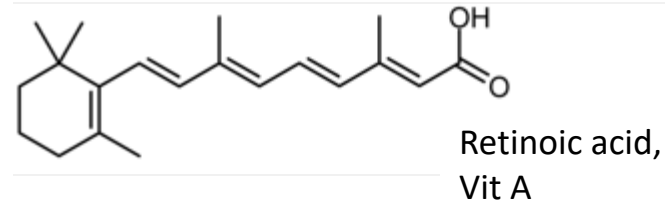


*Smith et al (2007) Curr Op Plant Biol* **10**: 266–275

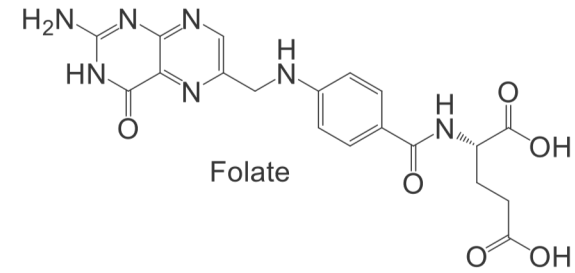


# Vitamin deficiency - consequences

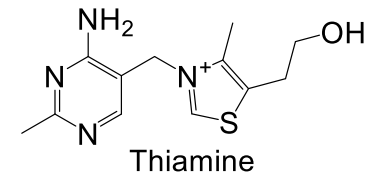
- Vitamin A deficiency – blindness

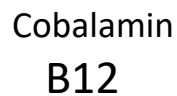


- Folate (B9) deficiency – neural tube defects



- Thiamine (B1) deficiency – beri-beri, also lassitude & impaired mobility





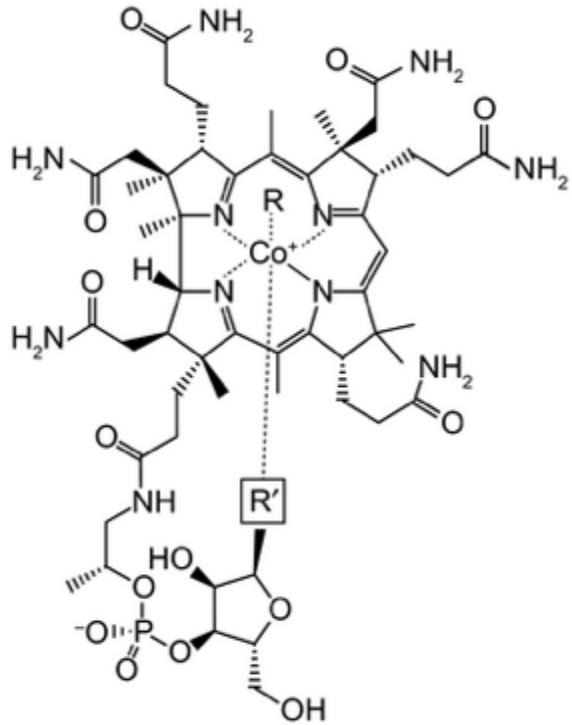
- Neuropathy and 'malaise'
- Associated with cognitive impairment/decline

- Not made by plants - only bacteria
- So strict vegetarians at risk of deficiency
- Reduced ability to absorb in elderly

*Croft et al. (2006) Eukaryotic Cell 5: 1175-1183*



# Algae need their vitamins – B12



- Nature's most complex 1° metabolite
- Essential enzyme cofactor
- Only made by (subset) of bacteria

- Not made by plants or fungi
- Nor by algae – but many use and require it





# Algae as source of vitamins

## Important Edible Algae – Sea Vegetables

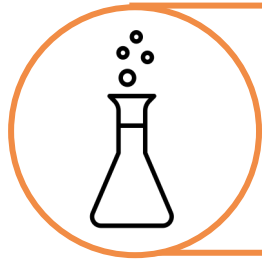
- Porphyra (“laver”) and Pyropia (“nori”)
  - commercially important human foods based on high mineral, protein, and vitamin content



Vitamin	Content mg per 100g dry weight			
	B <sub>12</sub>	C	E	A
Porphyra sp. <sup>1</sup>	0.070	33	0.340	4 - 25 <sup>3</sup>
Liver <sup>2</sup>	0.110	23	-	6.5

<sup>1</sup>Wells et al (2017) J Appl Phycol 29:949–982      <sup>2</sup>Wikipedia  
<sup>3</sup>provitamin A, ie  $\beta$ -carotene

2  $\mu$ g/day is RDA for B12



# Can algae provide bioavailable B<sub>12</sub>?

## Increasing vitamin B<sub>12</sub> availability in India

*Global Challenges Research Fund (GCRF) awards*

University of  
**Kent**



Algal growth  
with edible  
bacteria

Dietary intervention trials in Pune



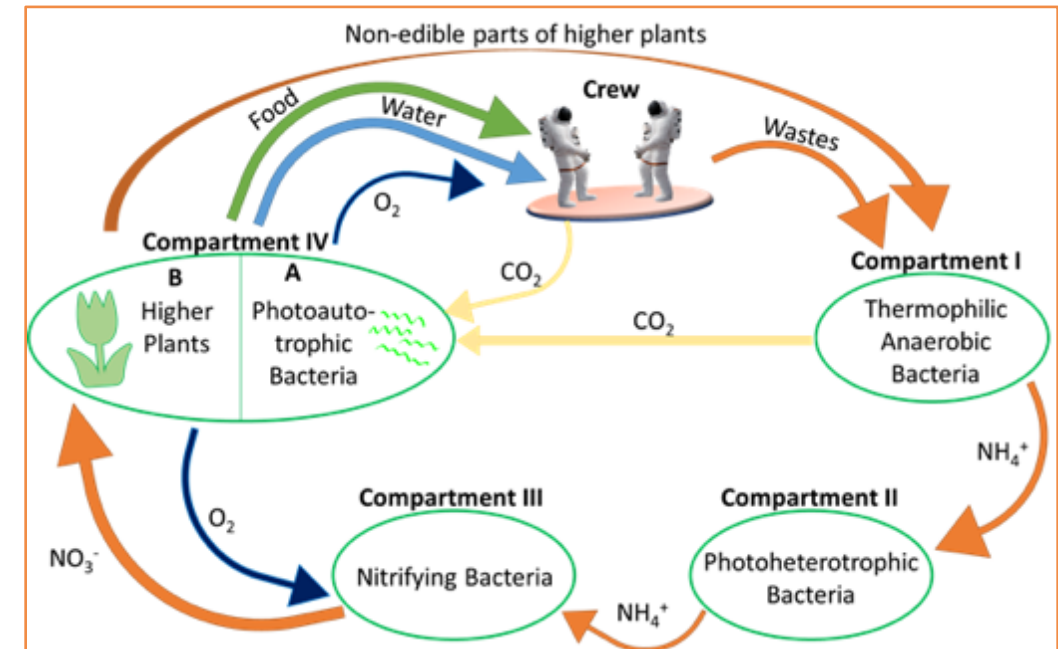
**Algal Biomass  
with high B<sub>12</sub> content**





# Exploiting the mutualism to increase B<sub>12</sub> availability

- Sustainable natural production of vitamins for human consumption in long space missions



Adapted from <https://www.melissafoundation.org/>



# Commercial exploitation of microalgae



*Algal Innovation Centre Glasshouse, University of Cambridge*

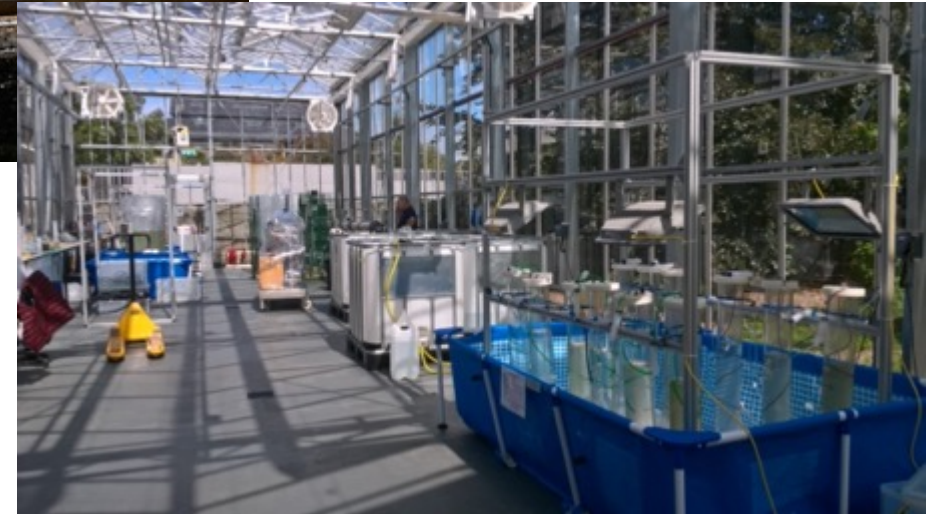


- Don't compete with traditional agriculture for land and potable/fresh water
- Fast growth rate (productivity- yield per unit time per unit area- may be 20x > land plants)
- Valuable compounds - vitamins, omega 3s, pigments (astaxanthin, beta carotene)
- Can be cultivated at industrial scale in photo-bioreactors

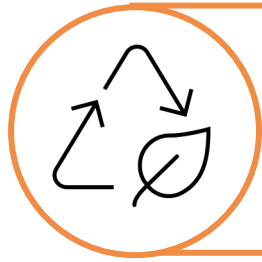


# Algal Innovation Centre

- In Cambridge Botanic Garden
- Test facility to develop pipeline of algal-based solutions
- Autotrophic and Heterotrophic Growth – DEFRA licenced



<http://www.camplants.group.cam.ac.uk/cambridge-bioenergy-initiative/algal-biotechnology-consortium-abc/aic>



# Circular photosynthesis- valorising waste

Using market/vegetable waste in Ghana



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Animal feed

Algal biomass

Crop waste

Anaerobic  
digestion

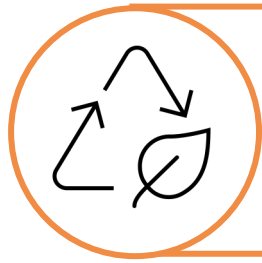
Biogas

Digestate

Algal growth

Clean(er) water

Global Challenges Research Fund (GCRF) awards



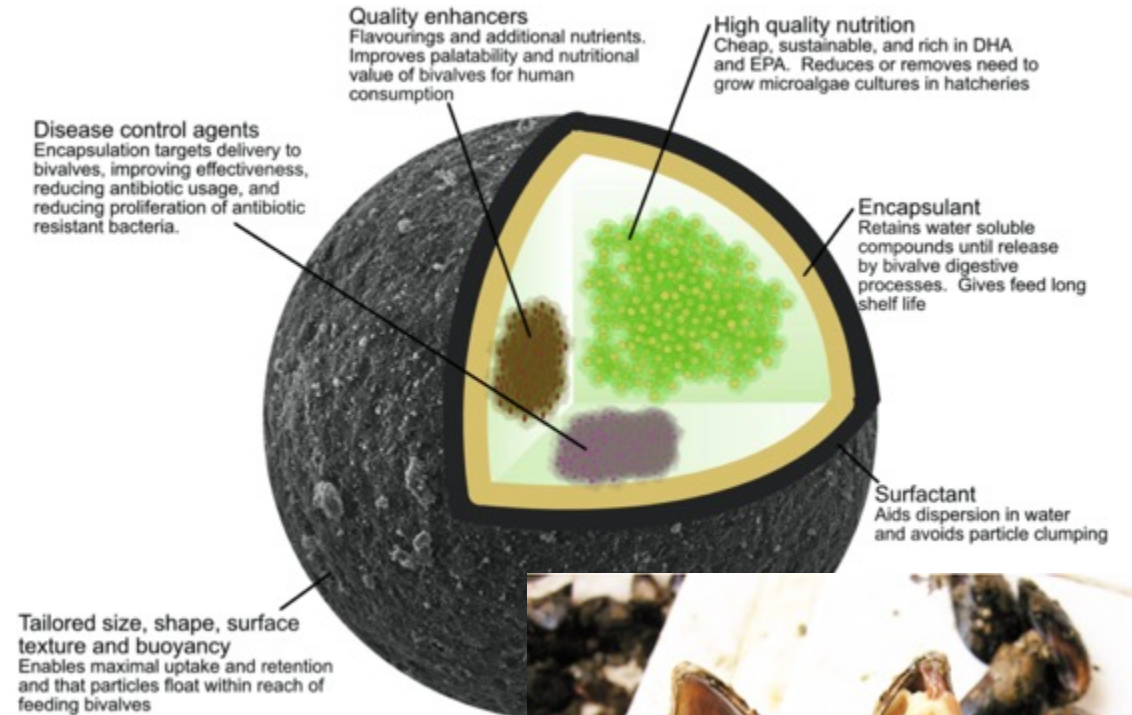
# Circular valorization aided by encapsulation



Dr David Aldridge



Dr David Willer



"Microencapsulated diets to improve bivalve shellfish aquaculture for global food security": <https://www.sciencedirect.com/science/article/pii/S2211912418300336>



# Back to the future kitchen



**CHLORELLA**  
Lime



**CHLORELLA**  
White



**CHLORELLA**  
Yellow



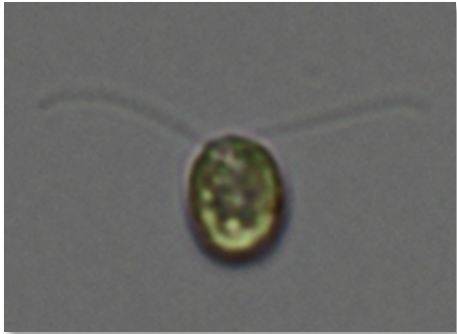
Join the revolution with our ground-breaking Chlorella Colours® platform







# Summary



- Algae, especially microalgae, are amazingly diverse
- Offer potential for many commercial exploitation
- Algae can be high in proteins, vitamins and other important nutritional compounds
- Algae, and their communities, may help provide more sustainable food sources in the future





# Acknowledgements

