

Payam Mehrshahi
University of Cambridge, UK



Algae: Food for the Future Kitchen

Algae: Food for the Future



Challenges for future food



What are algae?



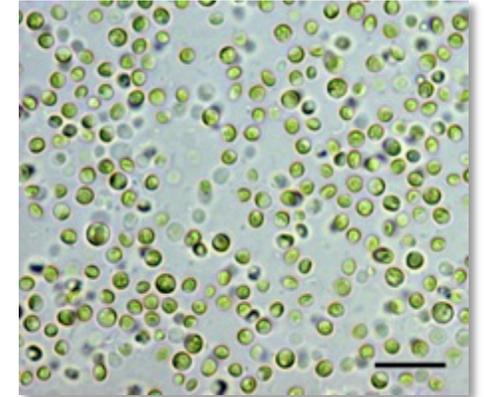
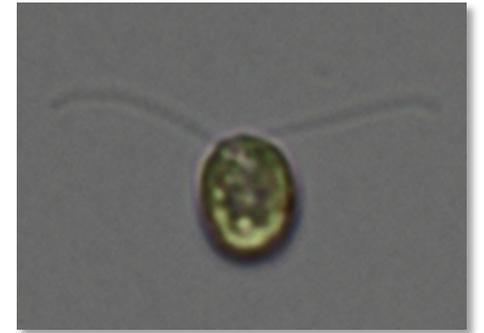
Algae for food and feed

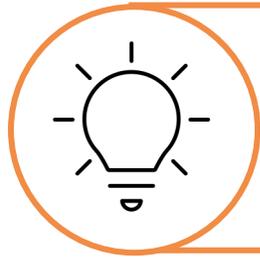


Cultivating algae at scale



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

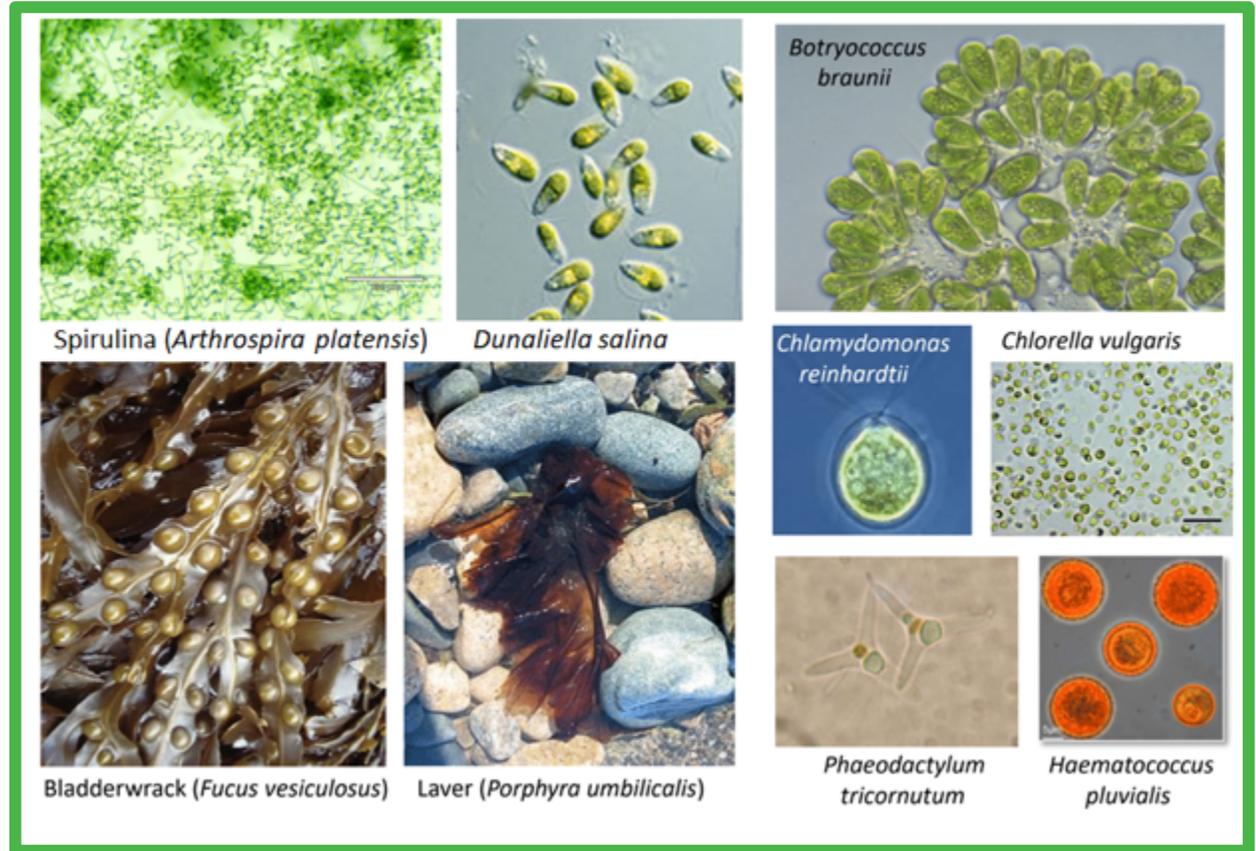


PARTNERSHIPS
FOR THE GOALS



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

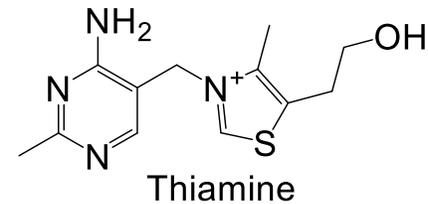


What are “Vitamins” in organisms?

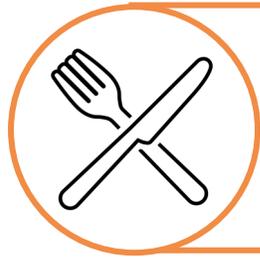


- Organic micronutrients that are required for growth

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

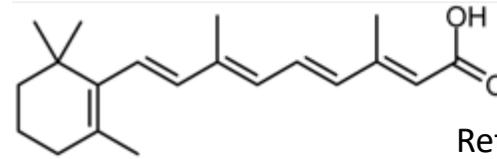


Smith et al (2007) Curr Op Plant Biol 10: 266–275



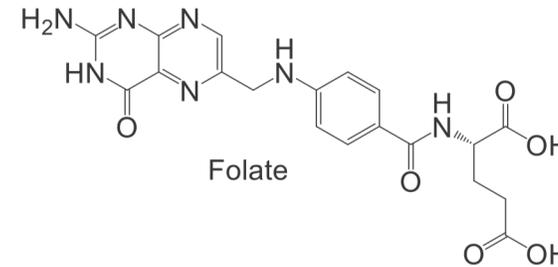
Vitamin deficiency - consequences

- Vitamin A deficiency – blindness



Retinoic acid,
Vit A

- Folate (B9) deficiency – neural tube defects

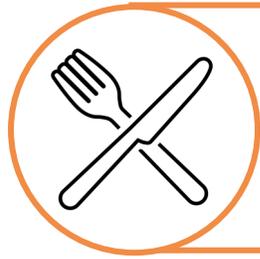


Folate

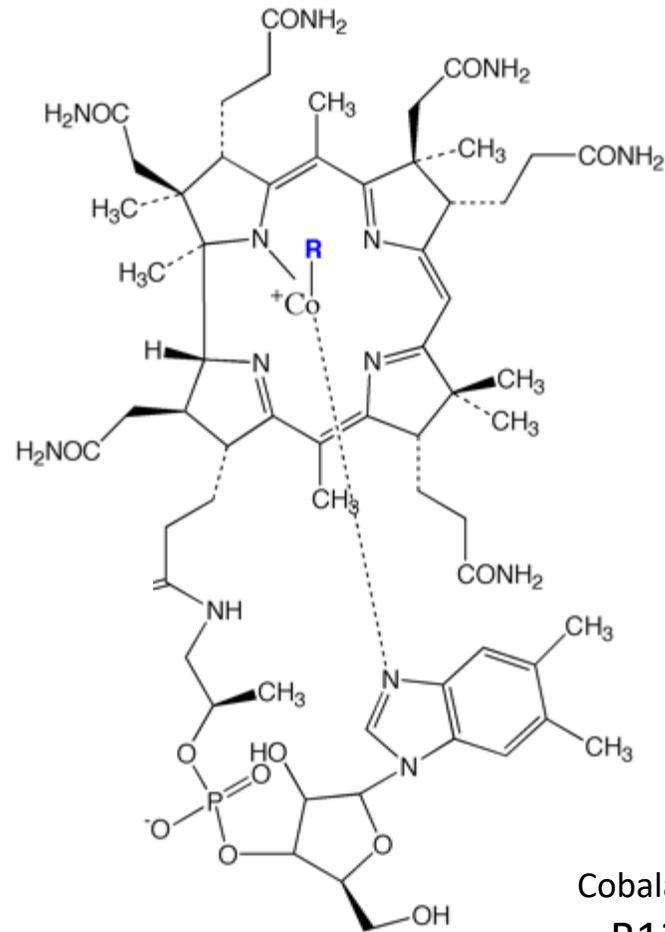
- Thiamine (B1) deficiency – beri-beri, also lassitude & impaired mobility



Thiamine



Vitamin B12 in humans



Cobalamin
B12

Vitamin B₁₂, cobalamin (pernicious anaemia factor)

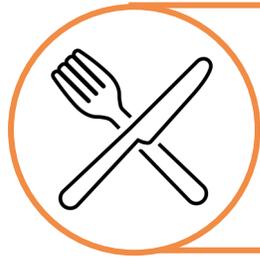
- Neuropathy and 'malaise'
- Associated with cognitive impairment/decline

Source for human diet - animal products

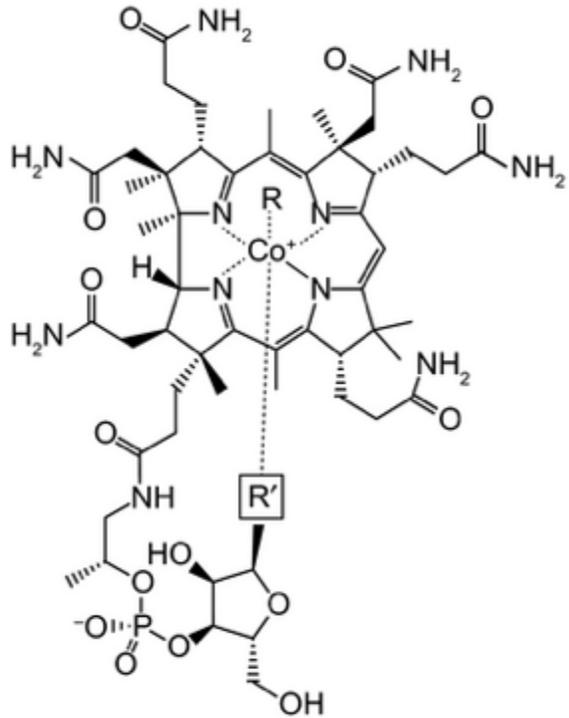
- Not made by plants - only bacteria
- So strict vegetarians at risk of deficiency
- Reduced ability to absorb in elderly

Croft et al. (2005) Nature **438**: 90-93

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

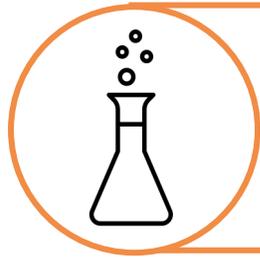
- Porphyra (“laver”) and Pyropia (“nori”)
 - commercially important human foods based on high mineral, protein, and vitamin content



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

¹Wells et al (2017) J Appl Phycol 29:949–982 ²Wikipedia
³provitamin A, ie β -carotene

2 μ g/day is RDA for B12



Can algae provide bioavailable B₁₂?

Increasing vitamin B₁₂ availability in India

Global Challenges Research Fund (GCRF) awards

University of
Kent



Algal growth
with edible
bacteria



**Algal Biomass
with high B₁₂ content**

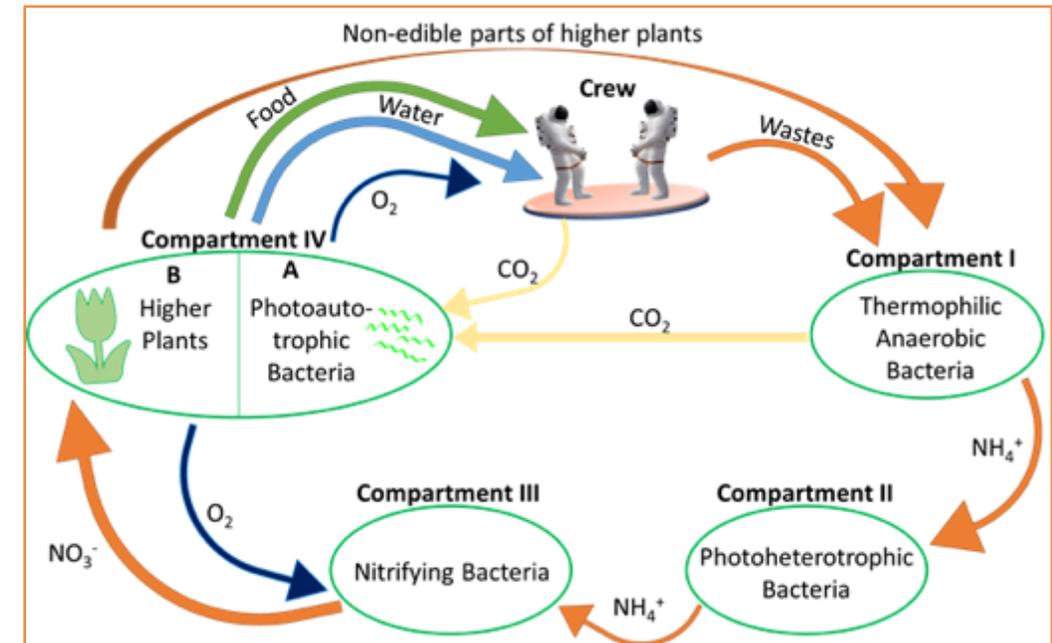
Dietary intervention trials in Pune





Exploiting the mutualism to increase B₁₂ 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

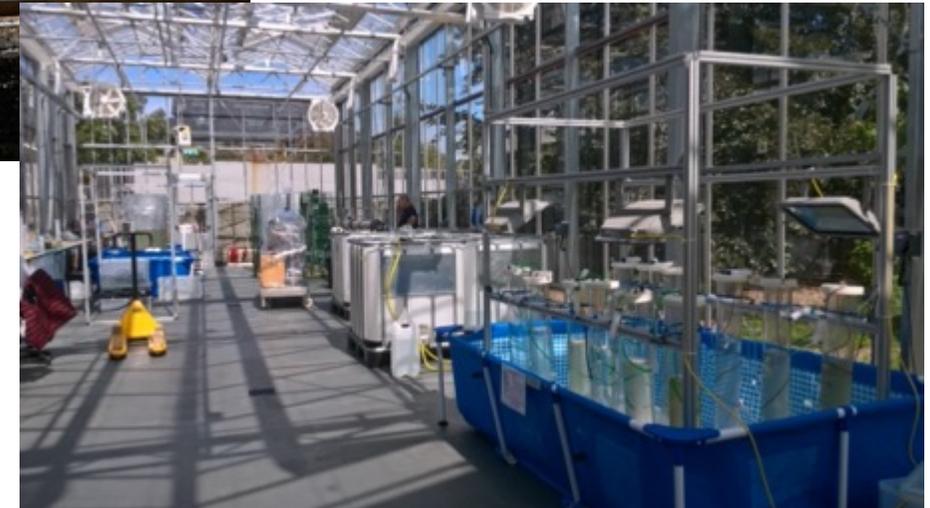


- Don't compete with traditional agriculture for land and potable/fresh water
- Fast growth rate (productivity- yield per unit time per unit area- may be 20x > land plants)
- Valuable compounds - vitamins, omega 3s, pigments (astaxanthin, beta carotene)
- Can be cultivated at industrial scale in photo-bioreactors

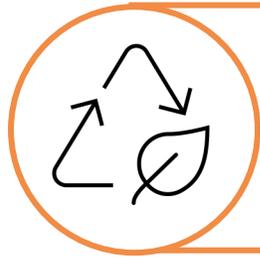


Algal Innovation Centre

- 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>



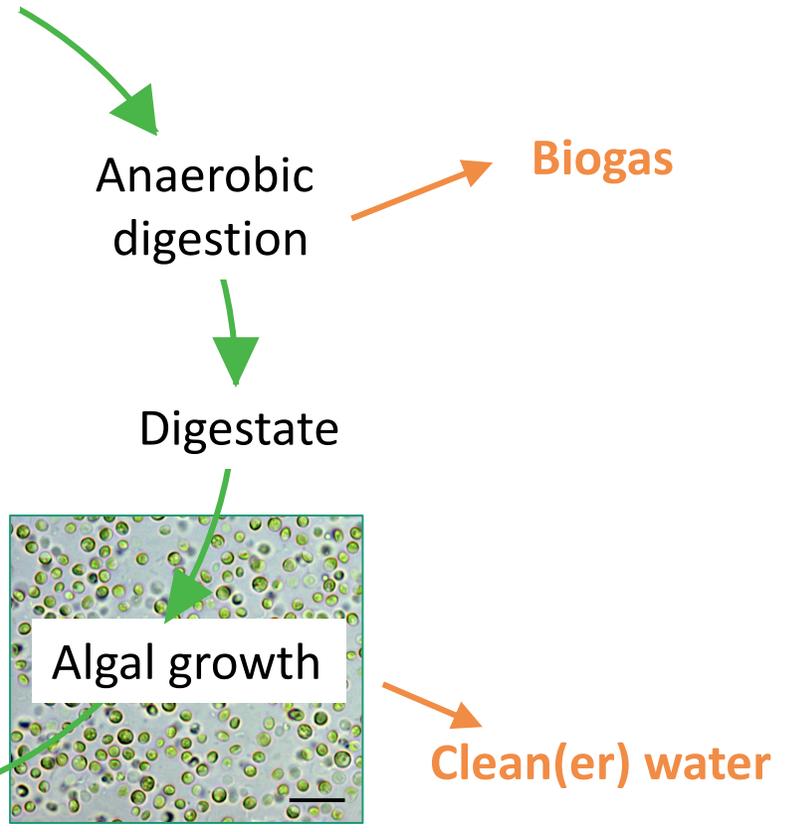
Circular photosynthesis- valorising waste

Using market/vegetable waste in Ghana



Global Challenges Research Fund (GCRF) awards

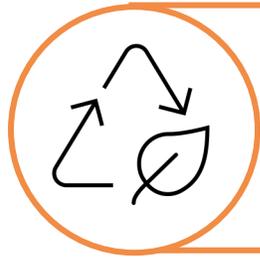
Crop waste



Animal feed

Algal biomass

Clean(er) water



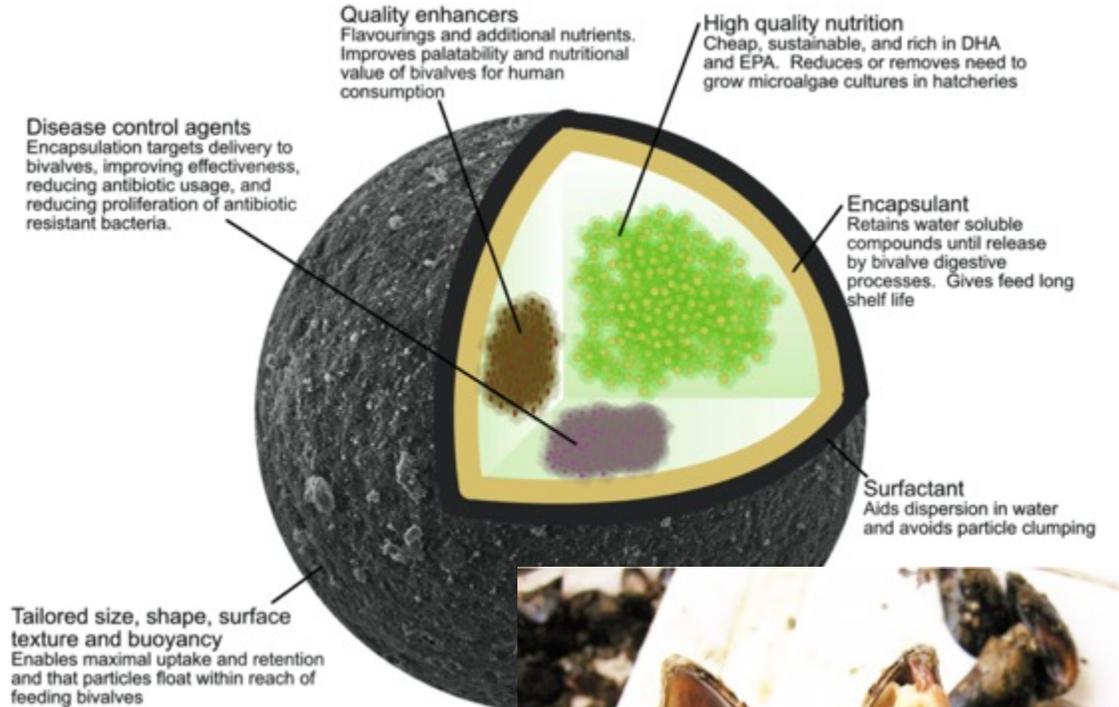
Circular valorization aided by encapsulation



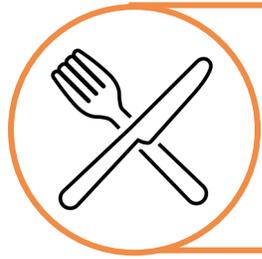
Dr David Aldridge



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





Back to the future kitchen

Microalgae biostimulant, bioprotectant for sustainable farming

Mejoras en la producción

Biorizon biotech

de VIÑEDOS

Biopotenciadores
Nutricionales

Witech eco

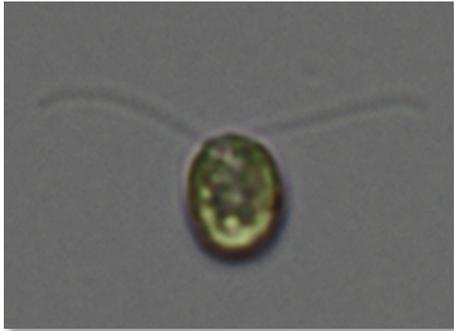
ecovine

Image showing a bunch of grapes and several product bottles.





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

