LOWERING THE COSTS OF BIOMASS PRODUCTION AND PRODUCT RECOVERY

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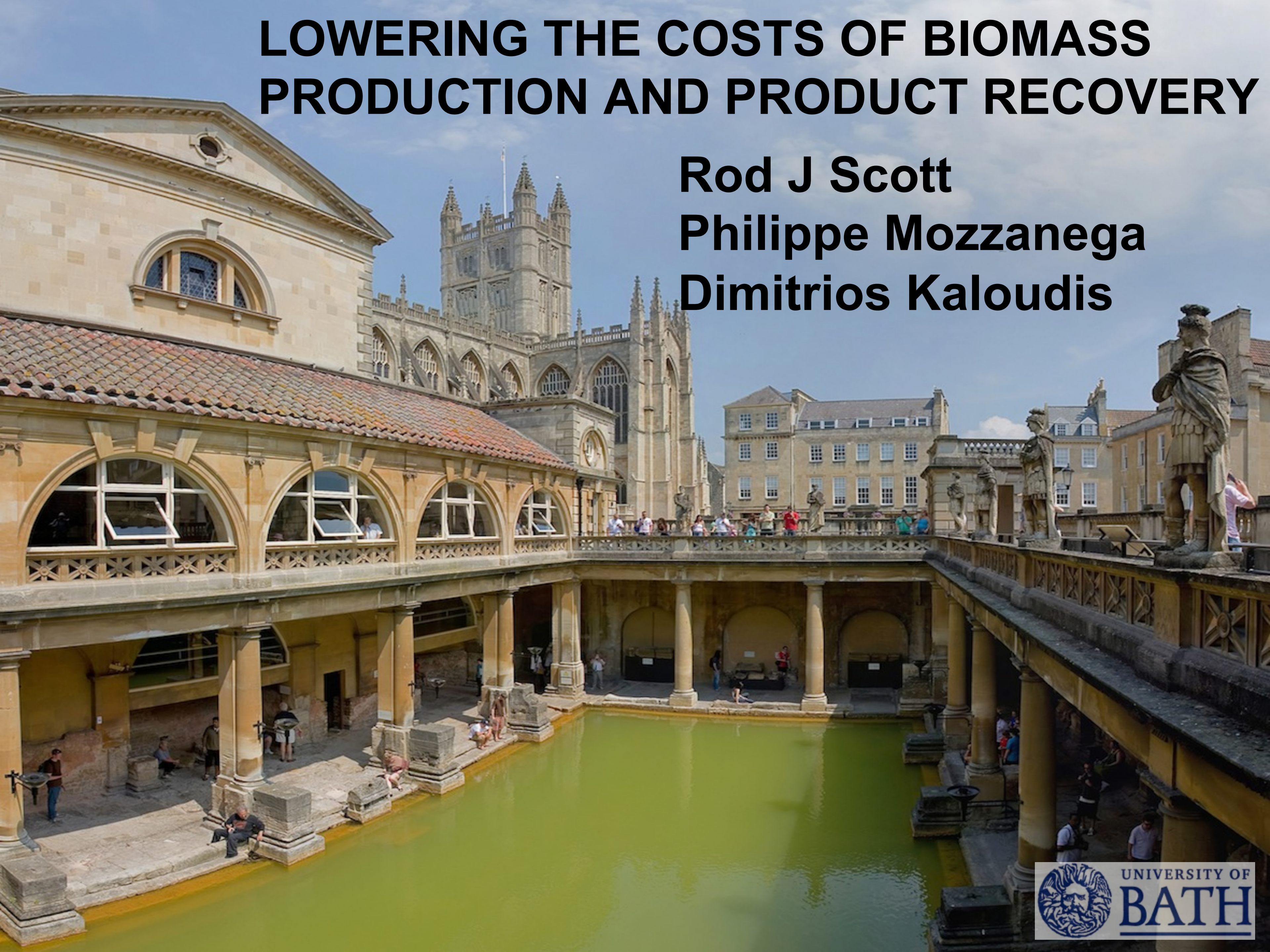
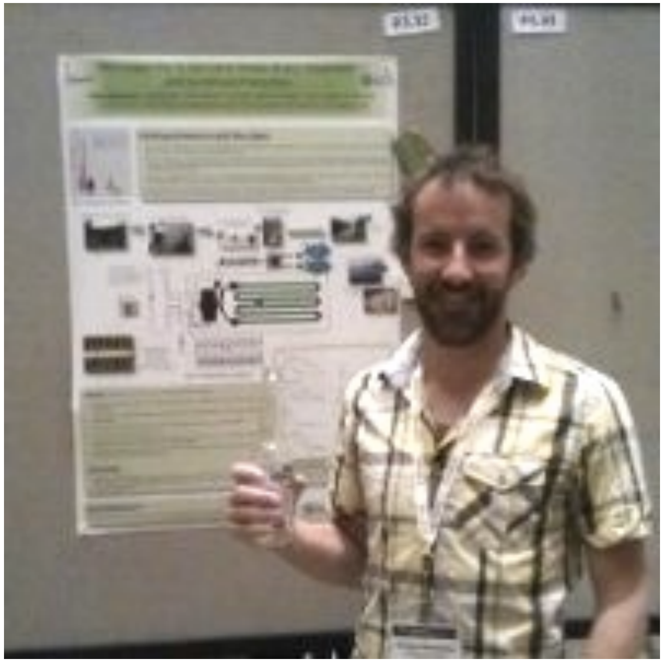


Outline

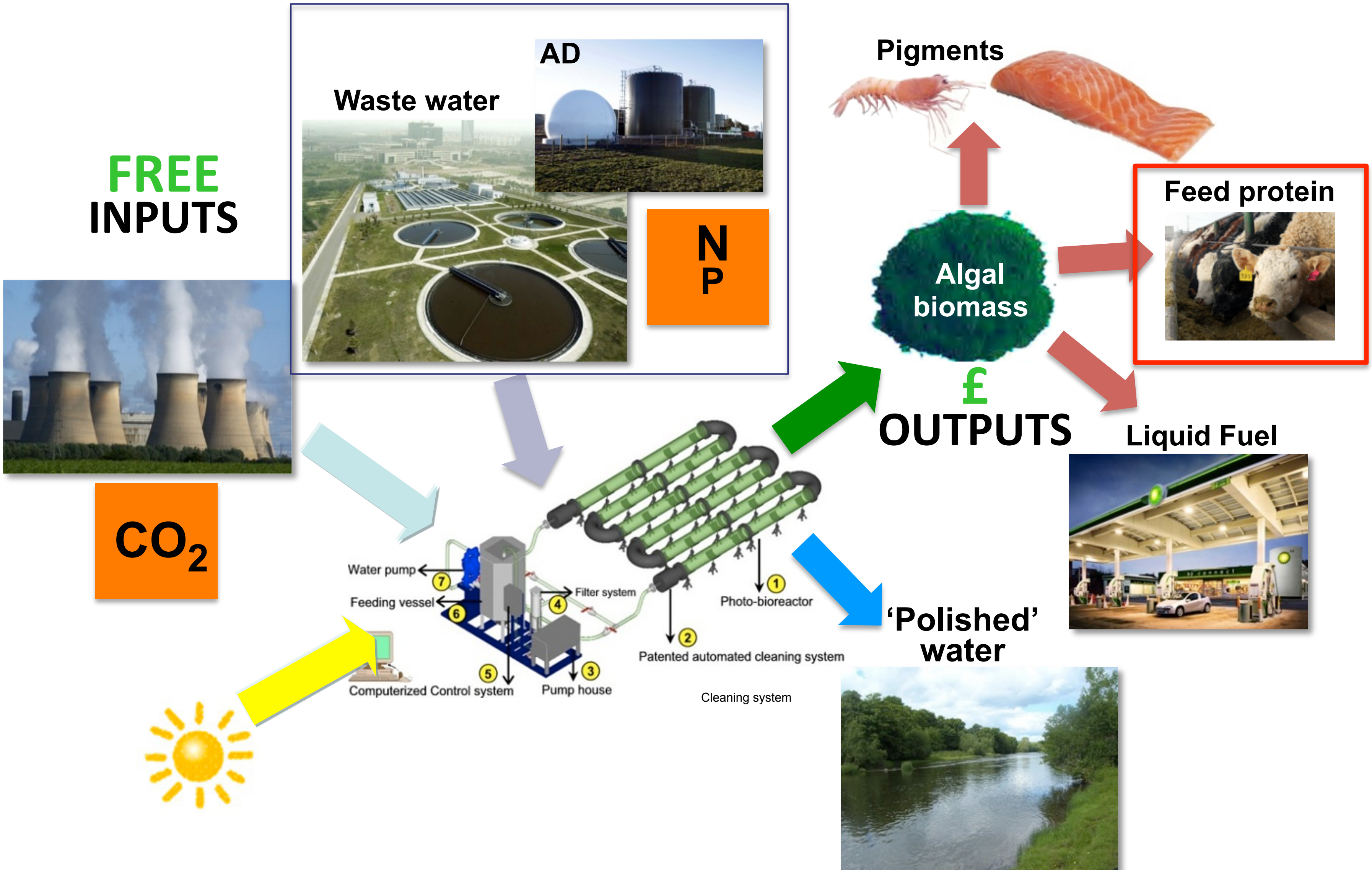
- Waste feed-stocks and Co-products key to reducing production costs

- Cell wall composition – an important factor in fitting species to purpose

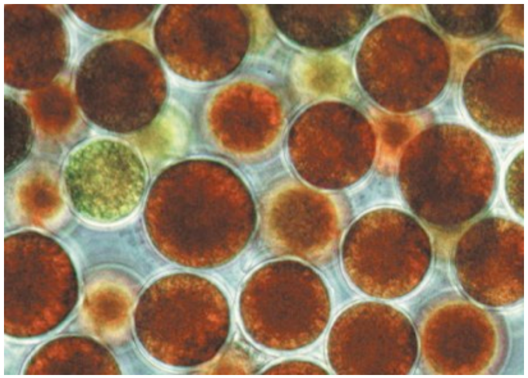
Philippe Mozzanega

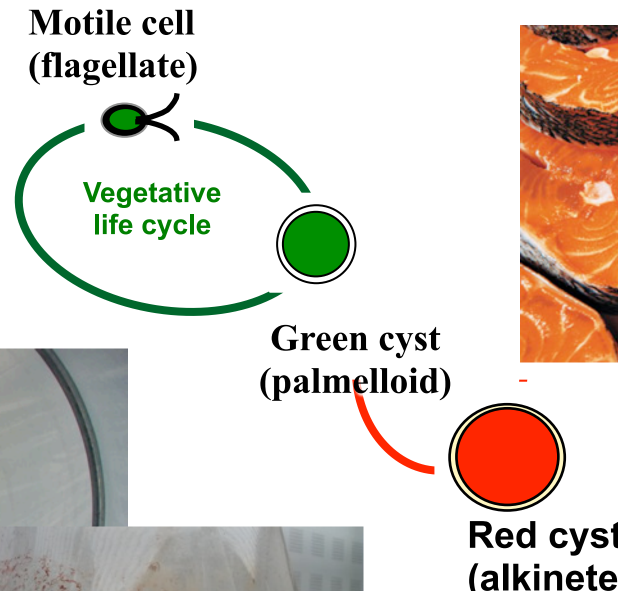


Waste feedstocks and Co-products key to reducing production costs



Contamination





Scenedesmus in WW final effluent

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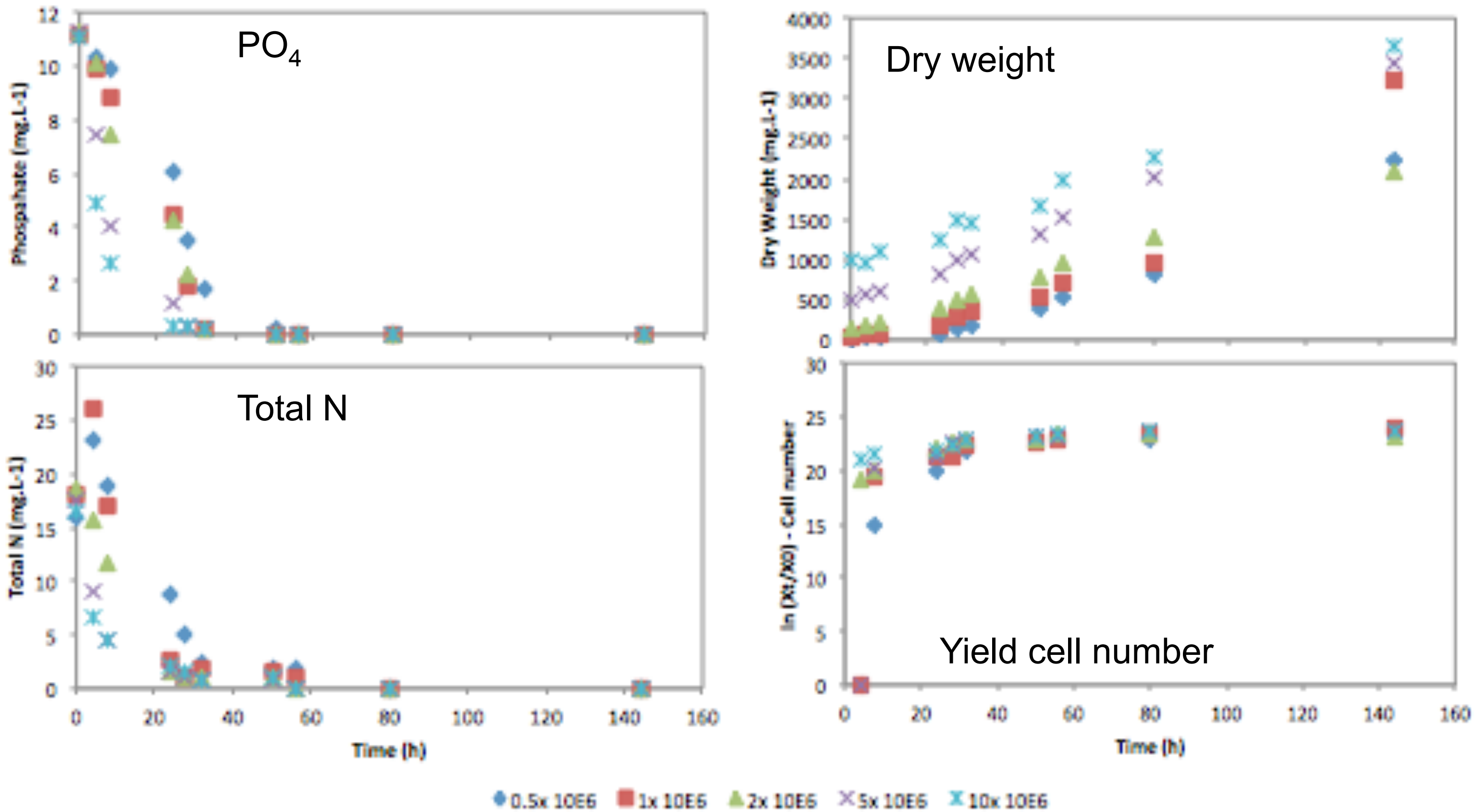
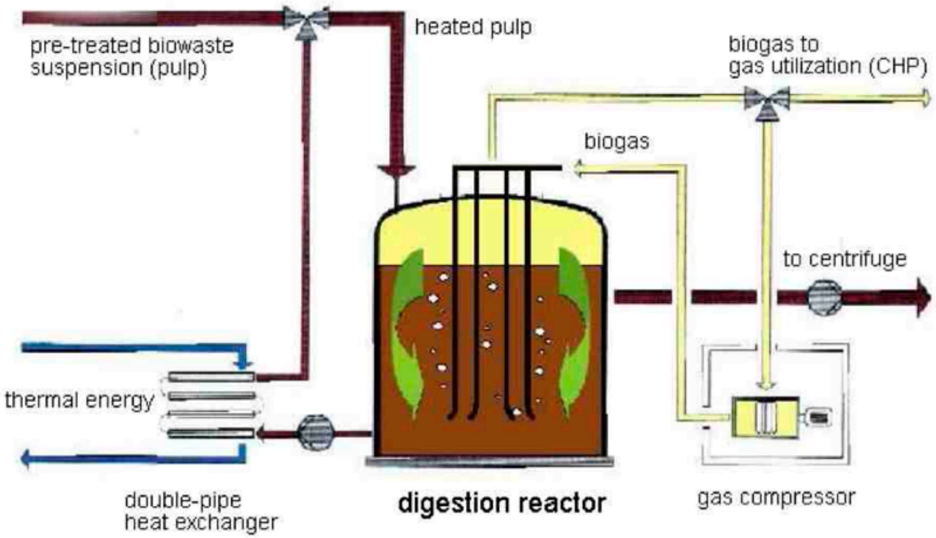
Wessex Water
a YTL company

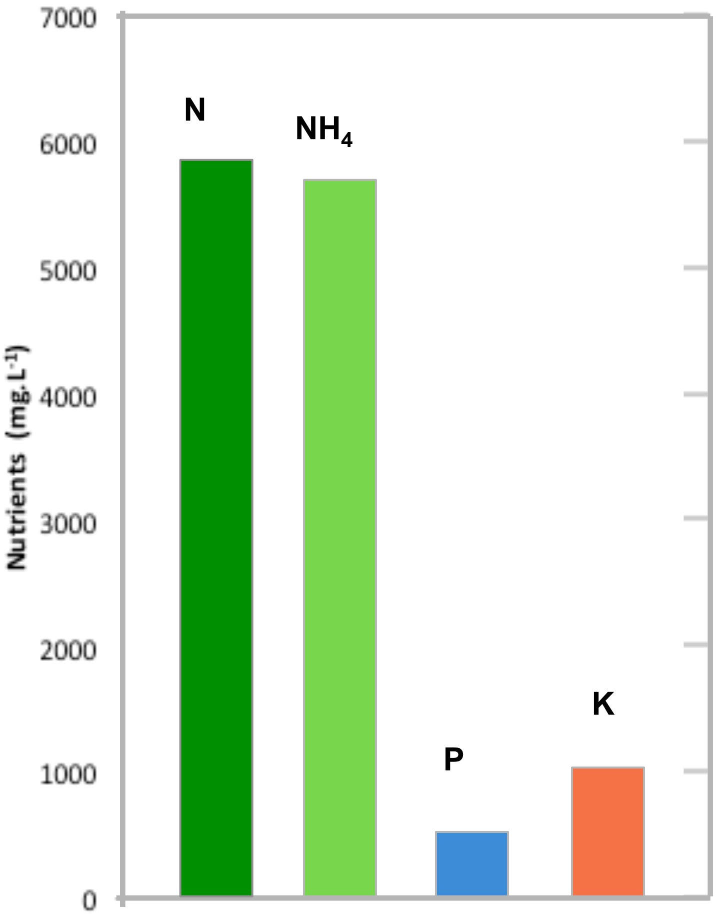
- *Scenedesmus* is ubiquitous in WWTW
- Rapid growth & resilience, accumulates >50% protein (dw)
    - Ideal candidate for utilizing an NPK-rich effluent waste stream



TOTAL nutrient depletion within 24hrs @ cell densities >2 millions/ml

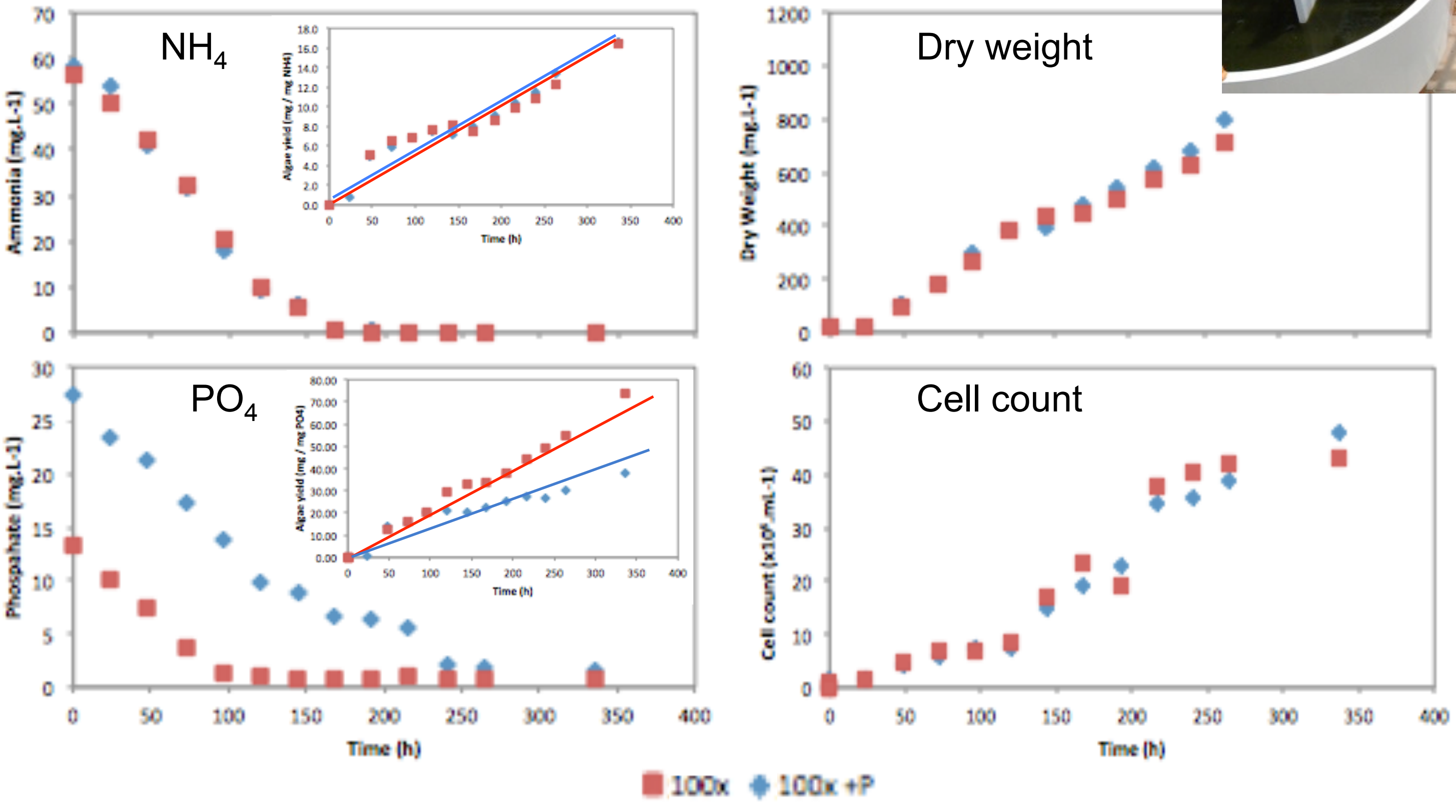
AD and digestate – a NPK-rich stream





WW = 25 mg/L N & 5 mg/L P

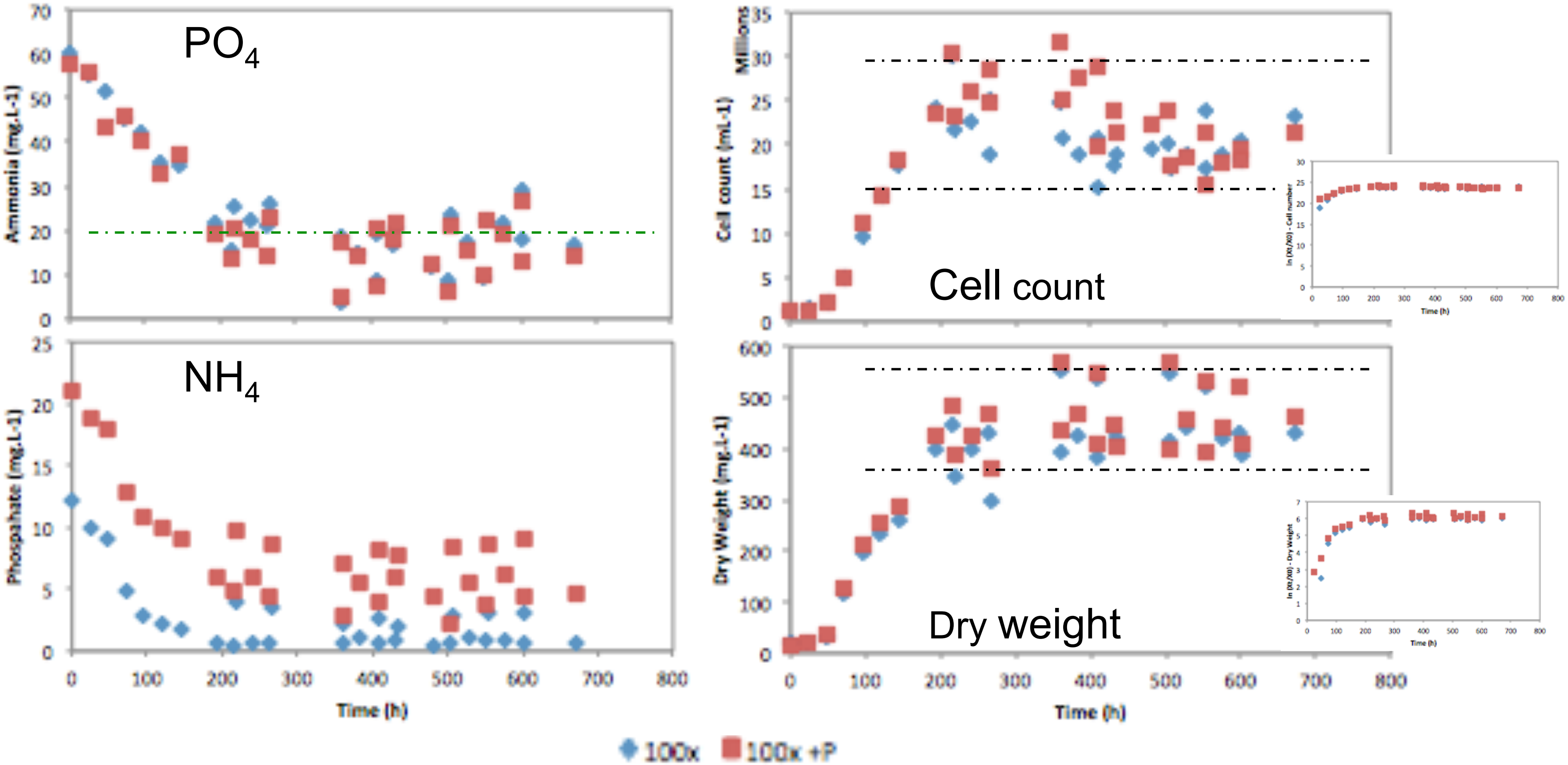
Scenedesmus obliquus in AD digestate in open raceway ponds – P supplementation



No benefit to P supplementation

Semi-continuous culture in open raceway ponds
(*Scendedesmus obliquus*)

20% daily renewal rate



> 0.5 $g_{dw}.L^{-1}.d^{-1}$at 45-50% protein

10g/day

Issues - bioaccumulation

Priority substances under the Water Framework Directive (Annex II of Directive 2008/105/EC)

33 substances:

Alachlor

Atrazine

Benzene

Brominated diphenyletheriv

Pentabromodiphenylether

Cadmium and its compounds

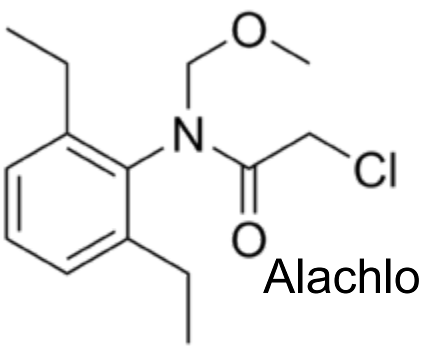
Chloroalkanes

Chlorfenvinphos

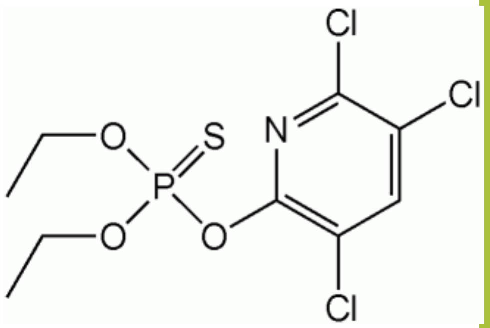
Chlorpyrifos

1,2-Dichloroethane

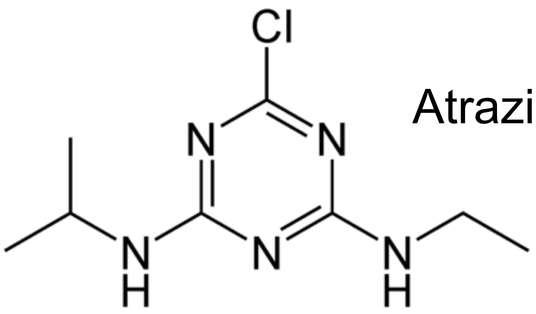
etc, etc



Alachlor



Chlorpyrifos



Atrazine

Cell wall composition – an important factor in fitting species to purpose

Algaenan cell walls in *Scenedesmus* sp. and other green algae of current and potential commercial importance

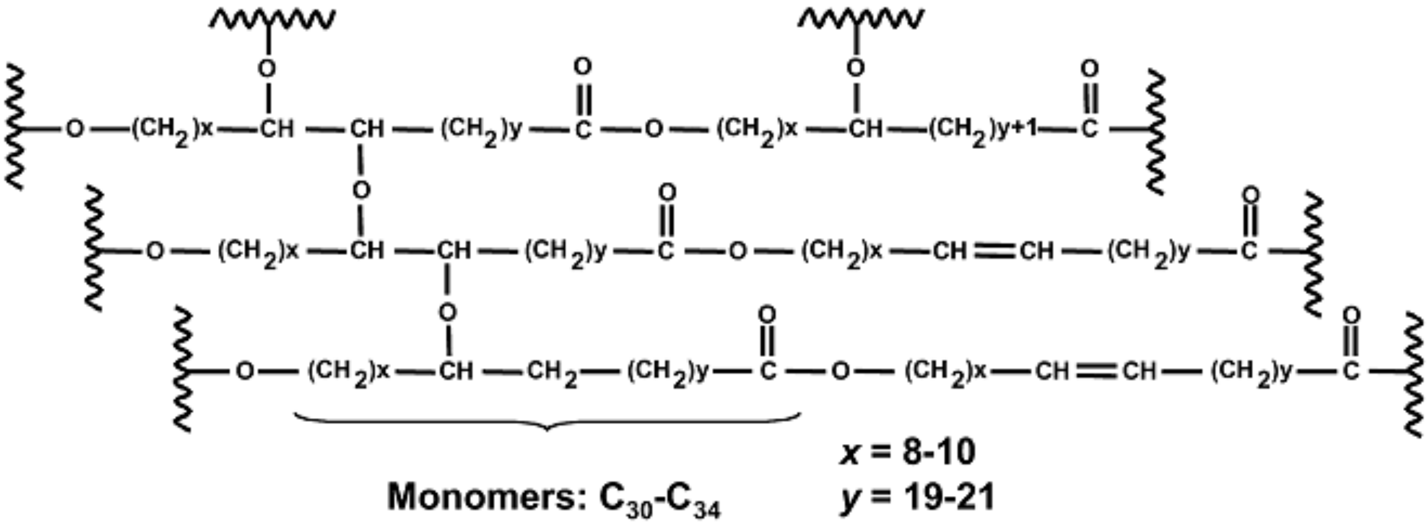
- Barrier for infection/predation.
- Waterproof, impermeable to solvents.
- **Low digestibility for animals.**
- Low digestibility in AD (biogas and algal nutrient recovery).
- Mechanically tough.

What is algaenan?

VLCFA (C_{18}-C_{36}) polyester heteropolymer.

Variable proportions of hydroxyacids, di-carboxylic acids and (α, ω) diols, saturated or mono-unsaturated.

Essentially a bio-plastic!



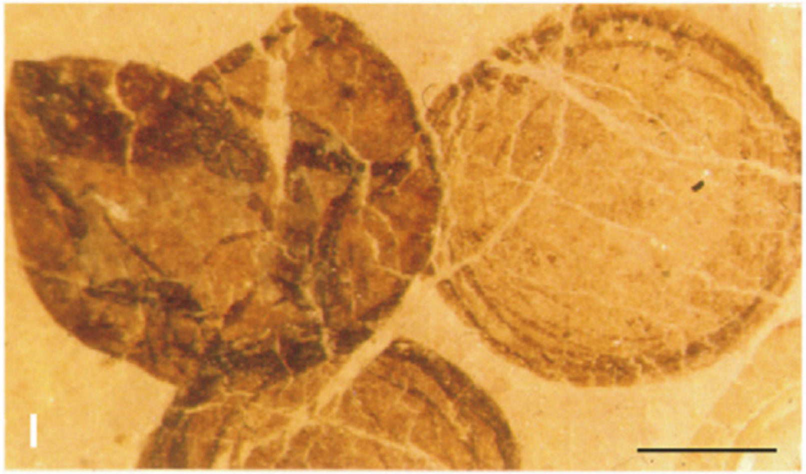
Versteegh and Blokker, 2004

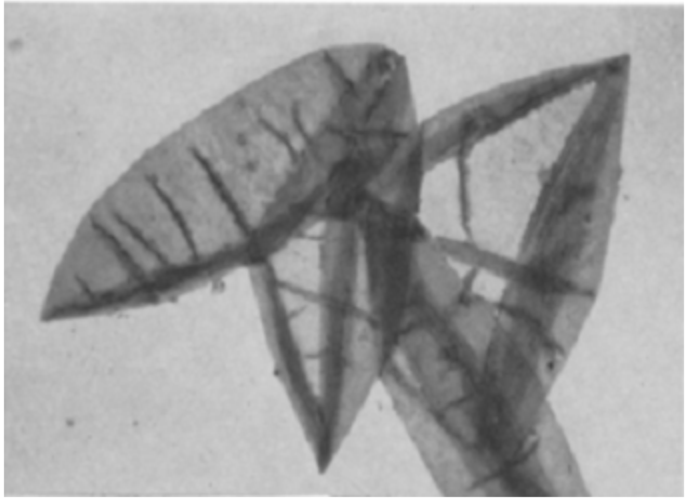
Evolution of algaenan and the global carbon cycle.

Proterozoic era (2.5-0.5 billion years ago).

Algaenan spores are abundant in the mid- and late Proterozoic fossil record (micro-FTIR) (Sharma *et al*., 2009)

Selective preservation hypothesis (Derenne *et al*., 1992; Blokker *et al*., 1998; 2006 and others)





Evolution of algaenan and the global carbon cycle.

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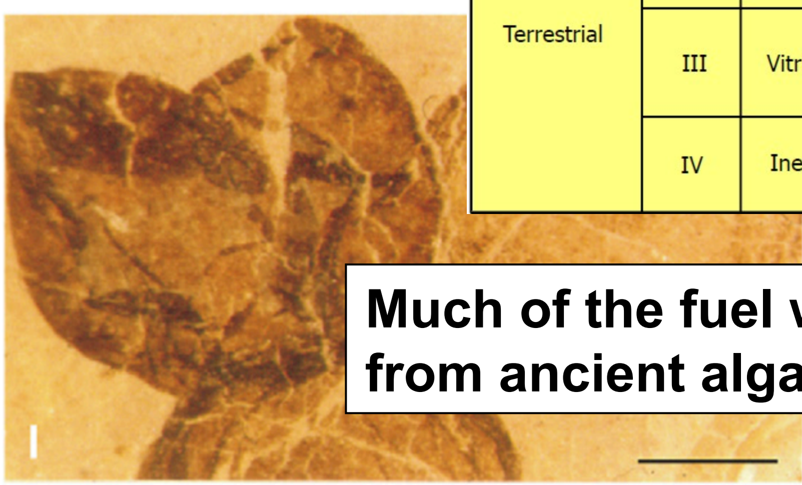
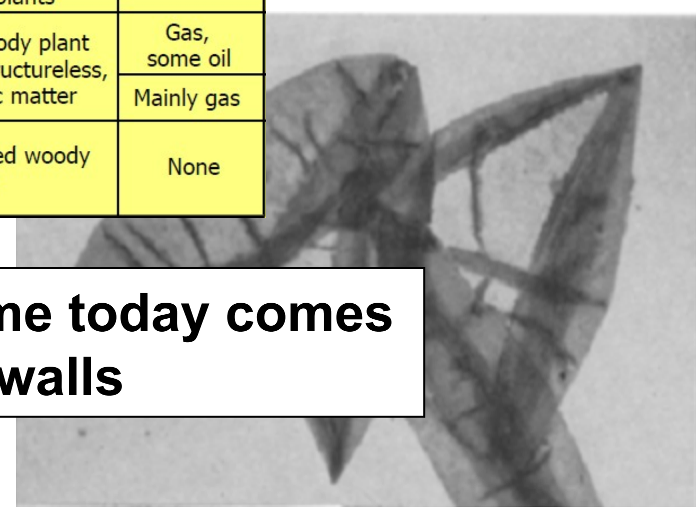
Algaenan spore … Proterozoic fossil record (micr…

Selective prese… ; Blokker *et al*., 1998; 2006 and other…

Types of Kerogen and Their Hydrocarbon Potential				
Environment	Kerogen Type	Kerogen Form	Origin	HC Potential
Aquatic	I	Alginite	Algal bodies	
		Amorphous Kerogen	Structureless debris of algal origin	Oil
			Structureless planktonic material, primairly of marine origin	
Terrestrial	II			
		Exinite	Skins of spores and pollen, cuticle of leaves and herbaceous plants	
	III	Vitrinite	Fibrous and woody plant fragments and structureless, colloidal humic matter	Gas, some oil
				Mainly gas
	IV	Inertinite	Oxidized, recycled woody debris	None

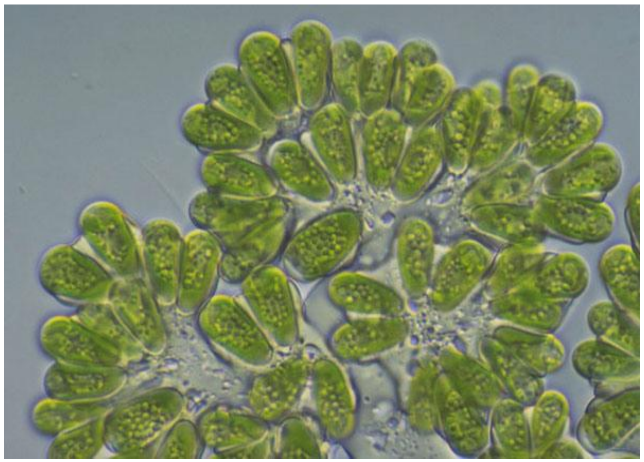




Much of the fuel we consume today comes from ancient algaenan cell walls

Occurrence

Green (Chlorophyta), freshwater microalgae and one marine coastal genus (*Nannochloropsis* spp.)
Many species of current or potential commercial importance.



Botryococcus braunii

Highest lipid content: ≈ 80% of dry weight under N starvation.

Nannochloropsis salina

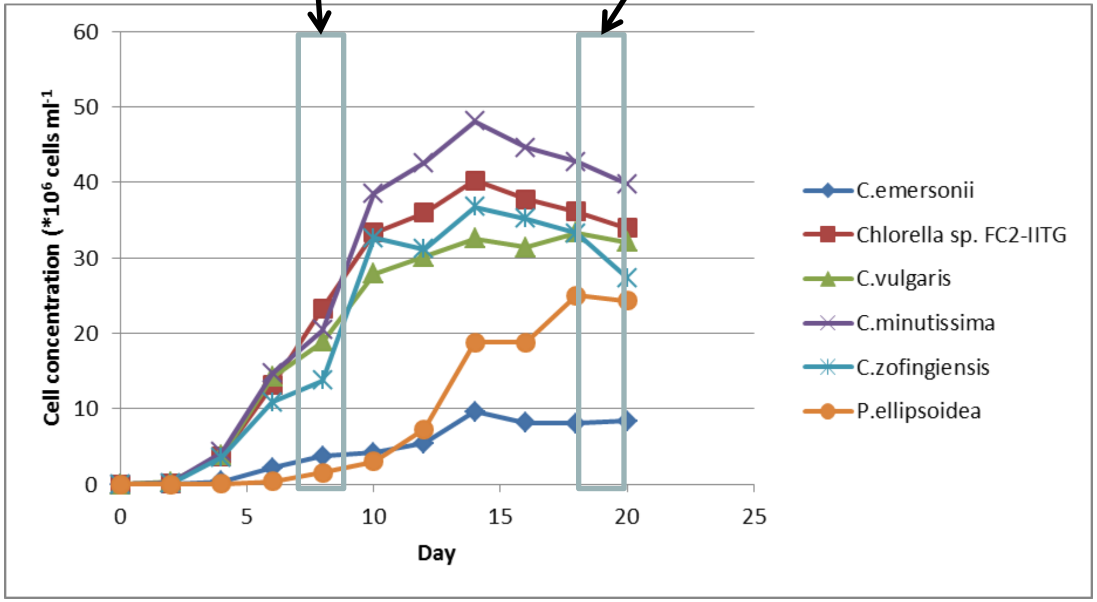
≈40-45% lipid content
Important PUFA source in marine aquaculture

A six-species screen of oleaginous microalgae to assess the effect of algaenan production and growth stage on the energy required for cell disruption.

Species	Strain	Algaenan
C.emersonii	CCAP 211/8b	+
C.vulgaris	CCAP 211/11b	-
C.minutissima	CCAP 211-52	+
C.zonfingiensis	CCAP 211/51	-
Chlorella sp.	FC2 IITG	-
P.ellipsoidea	N1	+

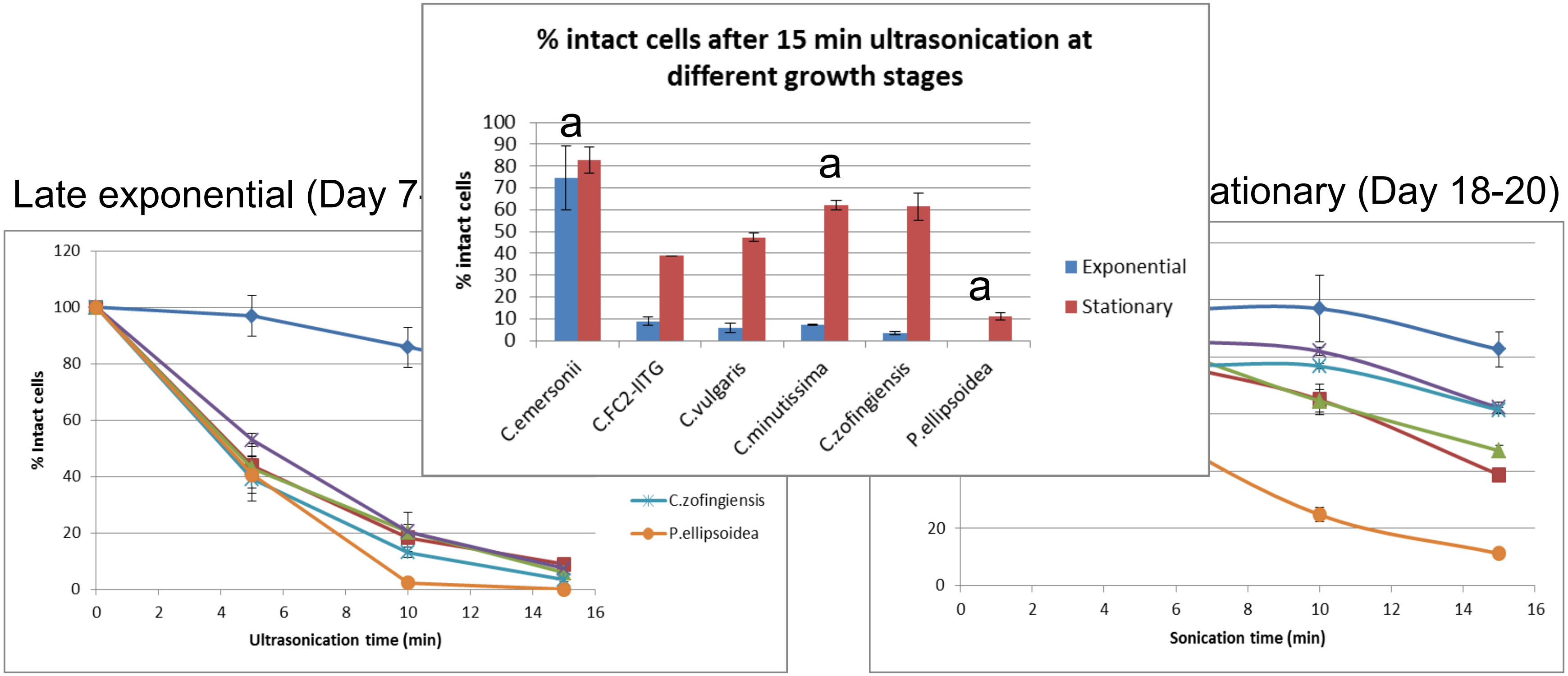
Ultrasonication at:

Late exponential phase   Stationary phase



A six-species screen of oleaginous microalgae to assess the effect of algaenan production and growth stage on the energy required for cell disruption.

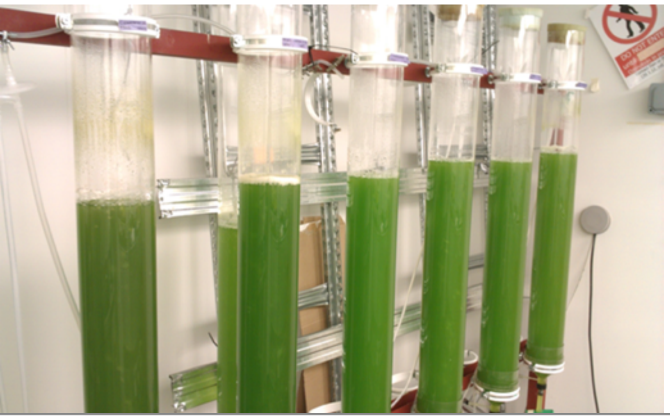
Late exponential (Day 7-



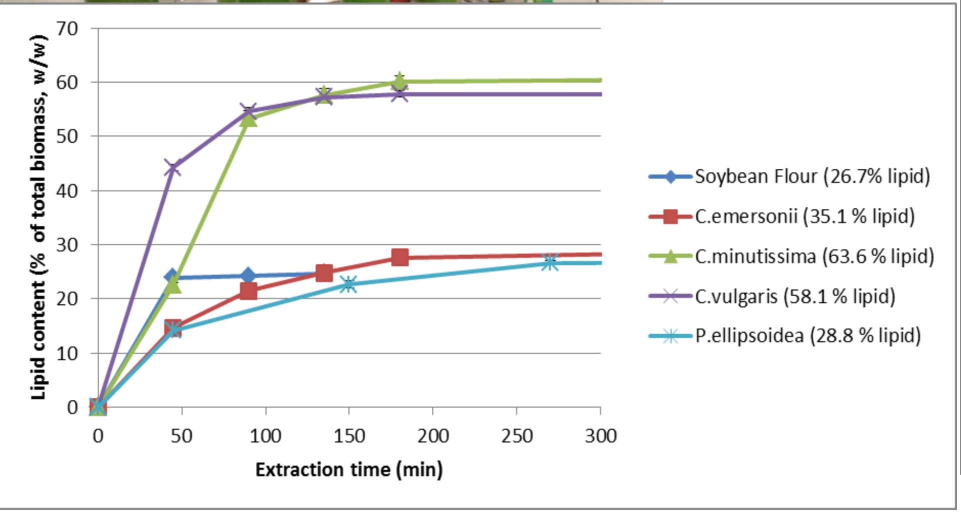
ationary (Day 18-20)

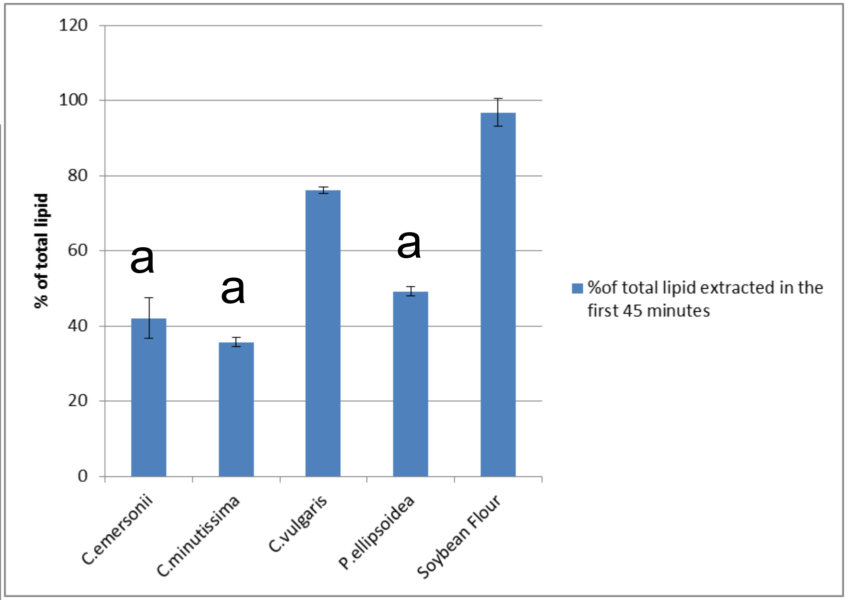
Growth stage more important than presence/absence of algaenan

The effect of cell wall composition on lipid extraction by solvents



- 20 days of culturing in 8L vPBRs.
- Comparison to full fat soybean flour.
- Chloroform/methanol extraction of lyophilized, undisrupted cells.





Algaenan reduces yield during extraction @ stationary phase

Conclusions

- Algaenan does not have a significant effect on the mechanical strength of microalgal cell walls.
- To reduce the costs of cell disruption, harvesting before stationary phase is more important than cell wall composition.
- Trade-off between N-starvation/lipid accumulation and processing costs.
- The presence of algaenan in the cell wall has a significant (negative) effect on solvent lipid extraction kinetics of undisrupted cells.

- **Algaenan-producing microalgae may be better suited for protein production than lipid accumulation**

- Hydrothermal liquefaction?

Acknowledgments

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