Mixotrophic Fermentation at Fermentalg
the best of both worlds

Hywel Griffiths
Chief Scientist
Who Are We?

French industrial biotechnology Company, founded in 2009

Over 50 employees working in a purpose built facility just outside Bordeaux

Listed on Euronext Paris since April 2014
A natural resource with an exceptional range of potential

Single-celled organisms that are half-plant, and half-animal

**Chloroplast** (photosynthesis): Autotrophic driver

**Mitochondrion** (respiration): Heterotrophic driver

- Lipids
- Pigments
- Proteins
- Polysaccharides
- Minerals
- Vitamins
- and others...
The March of Progress

<table>
<thead>
<tr>
<th>1950s: 1st generation</th>
<th>1980s: 2nd generation</th>
<th>1990s: 3rd generation</th>
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<tr>
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<td>5-10mg DCW/L/d</td>
<td>1-2g DCW/L/d</td>
<td>2-5g DCW/L/h</td>
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<td>Few players</td>
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Move towards more tightly controlled conditions – lower variability in product, greater opportunity to manipulate the cells to produce product.
Strain with good characteristics

Modify growth conditions to improve biomass productivity, product content, ease of downstream processing

Nitrogen source
minerals
pH
mixing

Carbon source
aeration
temperature

Scale-up to full industrial scale
Moving away from the natural environment?

But aren’t algae creatures of the light?
How do algae respond to light?

Cryptochrome
Phytochrome
Histidine Kinase
Rhodopsins
Aureochrome
Channel Rhodopsin
Chloroplasts
Chromoplasts

All these elements can affect gene expression either directly or indirectly
and genes control everything!

- Pigments
- Fatty acid synthesis
- Carbohydrate content
- Protein content
- Substrate utilisation
- Growth rate
Even in cells lacking chloroplasts, many of these light-regulated pathways still exist and still operate.
Strain with good characteristics

Modify growth conditions to improve biomass productivity, product content, ease of downstream processing

Nitrogen source
minerals
pH
mixing
Carbon source
aeration
temperature
Light Wavelength
Light Duration (Flash)

Scale-up to full industrial scale
**TECH**

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<td>Mixotrophy using predominantly heterotrophic conditions (fermenters + flash)</td>
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What does this mean?

Differences in growth rates, substrate utilisation and biomass accumulation can be quite marked.
End-to-End Development

Collect’Alg
Harvesting
Identification
Purification

Cellular Biology
High throughput screening
Characterization of strains

Alg’Up
Improvement in yields

Process Development
Development and optimization of the process

Downstream Process
Retrieval of molecules of interest in the biomass

Fermentalg
Breeding
Harvesting
Conservation (>1,800 strains)

Analysis Extraction Purification
Qualification and quantification of molecules of interest
Extraction and purification of molecules

Scale-up
Switch from 30L to 1,000 liters fermenters

Industrialization
Production in fermenters > 1,000L
Drafting of the Process Book
Transfer of technology to partners
Industrial Development

Application of light technology in purpose-built plant

- scale-up
- pre-industrialization
- sample production
- direct sales of product (400T oil/year)

Under Construction
A multitude of applications

- **Nutrition**
  - Proteins and lipids

- **Animal Feed**
  - Proteins and lipids

- **Cosmetics**
  - Emulsifiers

- **Green Chemistry**
  - Biopolymers
  - Biolubricants

- **Health**
  - Active ingredients
omega3
(EPA/DHA)

JOINT-VENTURE
Fermentalg (65%) &
Sofiproteol (35 %)
€ 7.0 bn in turnover
8,240 employees

COMMERCIALIZATION
(non-exclusive agreement)
Oleon (a Sofiproteol subsidiary)

MARKETS
• Oils
• Food supplements
• Child nutrition
• Nutraceutical
OBJECTIVE:
First sales in 2016
animal feed

High-volume markets
Compound feed (excluding petfood): € 50 bn in Europe*

Additives:
US$ 8.5 bn worldwide**

Group turnover 2011-2016: +6%/year***

Groundbreaking work
Next generation protein for animal feed

Model
Partnership (license + JV up to 50%)

* Source : FEFAC
** Source : DSM
*** :Markets & Markets (2011)