The role of the value-chain for the development of high-value products from microalgae
What is ‘high value’?

What is ‘economic relevance’?

What is the microalgae...

...value framework?
1. Value depends on **Composition**

- **Proteins**: 50%
- **Carbohydrates**: 20-30%
- **Polysaccharides**: (starch, glucose, sugars)
- **Lipids**: 20-30%
- **Other compounds**: < 5%
- **Essential vitamins**: (A, B1, B2, B6, B12, C, E, nicotinate, biotin, folic acid and pantothenic acid)
- **PUFAs**: (ARA, EPA, DHA)
- **Pigments**: (chlorophyll, carotenoids and astaxanthin)
- **Essential amino acids pattern similar to food**
2. Value depends on Applications

Current applications
- Food ingredients
- Healthfoods

Food
- Premix feeds
- Specialty feeds

Feed
- Nutraceuticals
- Pharmaceuticals

Health
- Cosmeceuticals
- Thalassotherapy

Cosmetics

Emerging applications
- Biofuels
- CO$_2$ mitigation

Fuels
- Biofertilizer
- Soil microalgae

Fertilizers
- N&P removal
- Bioremediation

Wastewater
- Biofibers
- Chemical industry

Chemicals
3. Value depends on **Formulation**

- Increasingly Market driven
  - Current product demand
  - New Products
  - Biorefinery concept
- Paste
  - Aquaculture
- Dried
  - Food & Feed
    - Aquaculture
    - Ceuticals
- Extracts
  - Ceuticals
Value-chain analysis is a complex topic very often mentioned by non-experts that bring a highly confusing, misleading and unclear approach.

The 'value-chain' is defined in a business context as: "the interrelated operating activities businesses perform during the process of converting raw materials into finished products".

The concept comes from business management and was first described and popularized by Michael Porter in his 1985 best-seller (Competitive Advantage: Creating and Sustaining Superior Performance).

Business value-chain  Product value-chain
> Value-chain for microalgae biomass

<table>
<thead>
<tr>
<th>PRIMARY</th>
<th>SUPPORT</th>
<th>PRODUCTS</th>
<th>APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>cultivating</td>
<td>harvesting</td>
<td>marketing</td>
<td>Aquaculture</td>
</tr>
<tr>
<td>&gt; packaging</td>
<td></td>
<td>logistics</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>technology</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>infrastructure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>management</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>wet biomass</td>
<td></td>
</tr>
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<td></td>
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<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRODUCTION</th>
<th>PROCESSING</th>
<th>DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>conditioning</td>
<td>solutioning</td>
<td>distribution</td>
</tr>
<tr>
<td>drying</td>
<td>extracting</td>
<td></td>
</tr>
<tr>
<td>&gt; packaging</td>
<td>&gt; packaging</td>
<td>broker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>client</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sales</td>
</tr>
<tr>
<td></td>
<td></td>
<td>procurement</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ingredient</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nutraceuticals</th>
<th>Nutraceuticals</th>
<th>Cosmeceuticals</th>
</tr>
</thead>
</table>
Value-chain for microalgae based products

The global microalgae value chain for any microalgae or microalgae based product can be quite simple or complex. Different steps where value is added along the process of transforming a biological material in a product for a client or even a consumer.

Different products can come-out in different points of the value-chain and they can be traded forward to the next point of the chain or further to other point.

Packaging defines a product that can be traded.
### Value-chain and market values > examples

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Production</td>
<td>2.720 – 3.050 ton/year</td>
<td>280 – 350 ton/year</td>
<td>5.900 – 7.000 ton/year</td>
<td>1.000 – 1.600 ton/year</td>
</tr>
<tr>
<td>Average Value</td>
<td>10 – 60 €/kg</td>
<td>150 – 340 €/kg</td>
<td>5 – 50 €/kg</td>
<td>60 – 100 €/kg</td>
</tr>
<tr>
<td>Total Value</td>
<td>95 – 106 M€/year</td>
<td>80 – 100 M€/year</td>
<td>120 – 160 M€/year</td>
<td>70 – 110 M€/year</td>
</tr>
</tbody>
</table>

### Value Chain

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trader Selling Price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food: 21 – 42 € / kg</td>
<td>1.5% astax: 110-126 € / Kg</td>
<td>2.0% astax: 150-167 € / Kg</td>
<td>Food: 6 – 21 € / kg</td>
<td>β-Carotene 211 – 2.114 € / kg</td>
</tr>
<tr>
<td>Food: 7 – 14 € / kg</td>
<td>3.0% astax: 210-252 € / Kg</td>
<td>100% asta liq.: 9K - 11K €/Kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Retail</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powder: 65 – 104 € / kg</td>
<td></td>
<td>Powder: 21 – 42 € / kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pills: 116 – 303 € / kg</td>
<td></td>
<td>Pills: 70 – 105 € / kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>End Consumer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powder: 180-222 € / kg</td>
<td></td>
<td>Powder: 110 – 116 € / kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tablets: 334-396 € / kg</td>
<td></td>
<td>Tablets: 150 – 217 € / kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capsules: 453-559 € / kg</td>
<td></td>
<td>Capsules: 53 – 108 € /kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granules: 199-363 € / kg</td>
<td></td>
<td>Liquid Ext.: 36 K € /kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CGF: 633 € / kg</td>
<td></td>
<td>Cream: 132 € /kg (whole formulation)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values for 2012 under updating
5. Value depends also on production Scale

<table>
<thead>
<tr>
<th>OPEN SYSTEM</th>
<th>CLOSED SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMALL SCALE</td>
<td>SMALL SCALE</td>
</tr>
<tr>
<td>&lt; 5 ha</td>
<td>&lt; 10 m³</td>
</tr>
<tr>
<td>production: 10-100 ton/year</td>
<td>production: &lt; 1 ton/year</td>
</tr>
<tr>
<td>more than 500 production facilities all over the world</td>
<td>more than 100 production facilities all over the world</td>
</tr>
<tr>
<td>MEDIUM SCALE</td>
<td>MEDIUM SCALE</td>
</tr>
<tr>
<td>5-50 ha</td>
<td>10-500 m³</td>
</tr>
<tr>
<td>production: 100-500 ton/year</td>
<td>production: 1-50 ton/year</td>
</tr>
<tr>
<td>less than 300 production facilities mostly in China and other Asian countries</td>
<td>less than 50 production facilities all over the world</td>
</tr>
<tr>
<td>LARGE SCALE</td>
<td>LARGE SCALE</td>
</tr>
<tr>
<td>50-100 ha</td>
<td>500-2,000 m³</td>
</tr>
<tr>
<td>production: 1000-5000 ton/y</td>
<td>production: 25-150 ton/year –</td>
</tr>
<tr>
<td>less than 20 Spirulina production facilities with this scale</td>
<td>less than 10 only 4 with more than 1,000 m³ (BGG, Algatch, Buggypower, Allmicroalgae)</td>
</tr>
<tr>
<td>VERY LARGE SCALE</td>
<td>VERY LARGE SCALE</td>
</tr>
<tr>
<td>&gt; 100 ha</td>
<td>&gt; 2,000 m³</td>
</tr>
<tr>
<td>&gt; 5,000 ton/year</td>
<td>&gt; 50-70 ton/year</td>
</tr>
<tr>
<td>still no production facility with this size</td>
<td>still no production facility with this size</td>
</tr>
</tbody>
</table>

there is also a very small scale > the microfarming with less than 0.5 ha

LARGE SCALE DEPENDS ON HOW WE COMPARE WITH REFERENCES
6. Value depends also on **comparative reference**

<table>
<thead>
<tr>
<th>Soy: oil &amp; meal</th>
<th>Fish: oil &amp; meal</th>
<th>Algae: oil &amp; meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 200 million ton/year of production</td>
<td>&gt; 7 million ton/year of production</td>
<td>&gt; 20 thousand ton/year of production</td>
</tr>
<tr>
<td>Feed applications are the most relevant</td>
<td>Feed applications are the most relevant</td>
<td>Food applications are the most relevant</td>
</tr>
<tr>
<td>Soy based feeds improved with fish meal</td>
<td>Fish meal feeds are improved with algae</td>
<td>Algae emerge as pre-mix feed ingredient</td>
</tr>
<tr>
<td>Current value &lt; 0.5 € typically 0.35 €/Kg</td>
<td>Current value &lt; 2 € typically 1.5 €/Kg</td>
<td>Current value &lt; 10 € typically 10-20 €/kg</td>
</tr>
</tbody>
</table>

**10 €/Kg is a high value**

... when compared with 0.35€/Kg related oil products
Feedstock demand

MARKET VALUE (DEMAND) FOR MICROALGAE BASED PRODUCTS (2012)

Product value (€/kg) - log scale

- Fucoxanthin
- Astaxanthin
- Beta-carotene
- Zeaxanthin
- GLA
- ARA
- EPA
- DHA
Same examples

- Aquaculture hatchery feeds
- Aquarium feeds
- Farm animal premix feeds
- Racing animal specialty feeds
- Pet foods ingredients

- Food ingredients
- Food supplements
- Nutraceuticals and health food
- Cosmetics and cosmeceutical

- Agriculture extracts
Aquaculture hatchery feeds

**Brine Shrimp Direct**

**Nannochloropsis**

- 125 ml - $13.95
- 500 ml - $35.95

[www.brineshrimpdirect.com](http://www.brineshrimpdirect.com)

---

**Necton**

*Nannochloropsis oculata* is the main cultured organism contained in PhytoBloom.

[www.necton.com](http://www.necton.com)

---

**Phylavive**

More than live algae and more than formulated products

[www.phylavive.com](http://www.phylavive.com)

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**TomAlgae**

[www.tomalgae.com](http://www.tomalgae.com)

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**Cloram-X** - 1 lb tub $11.25

**Reed Mariculture Inc**


**Nannochloropsis** + **Isochrysis**

- $75.00
- $47.25

---

*Source:* University of Sheffield
Aquarium feeds

Chlorella

www.bassleer.com

www.phytobloom.com

Spirulina

www.dobbies.com/

www.algaenergy.es/

www.petworldshop.com

www.coralculture.co.uk/

£15.58

£5.60

£29.99

£5.49
Farm animals premix feeds

www.tractorsupply.com/content_landing-page_dumor

www.actsinc.biz/algavit.html

DHA omega-3

Spirulina platensis, Haematococcus pluvialis, Chlorella sp, Chlorella protothecoides, Nannochloropsis sp, Chlorella sorokiniana,

www.dhagold.com

www.algaeinstitute.com

$18
Racing animal speciality feeds

Spirulina

DHA omega-3

www.springtimeinc.com/product/longevity/All-Natural-Dog-Supplements

www.nouvelieresearch.com

www.myshopping.com.au

www.algosud.com

www.dhapold.com
Pet food ingredients

Chlorella

www.watershed.net

$60

www.sunchlorellausa.com

$60

www.livelypets.com

DHA omega-3

Nutrition worth begging for!
Food ingredients

SPIRULINA

$1.19 / 1 Small Bar 14g

$5.49 / 3 oz Bag

www.goraw.com

Enerva Spirulina Cookies

Lee Biscuits (Pte.) Ltd.

Spirulina Filled Crackers
Packing: 24 x 176g

http://elkenenstek.blogspot.pt/2013/10/elken-everyday.html

http://m.shopclues.com/enerva-spirulina-cookies-2.html

O-Yes! Spirulina Cracker - 28 Sachets

http://elkenenstek.blogspot.pt/2013/10/elken-everyday.html

http://m.shopclues.com/enerva-spirulina-cookies-2.html

www.leebiscuits.com/pro03_filled_crackers.html

Food ingredients

CHLORELLA AND SPIRULINA INGREDIENTS

www.emmaandtom.com  www.jugojuice.com

€20,95

http://www.mattisson.nl/shop/superfoods/absolute_supersmoothie_slimming_mix_bio_raw/47

€42,40

www.organo.dxneurope.eu/products

http://www.bluebio.cn/

www.nl.nutress.eu
**Food ingredients**

**CHLORELLA AND SPIRULINA INGREDIENTS**

Spirulina contains 10-20% **phycocyanin** making it the best natural blue color for foods.

[www.algaeindustrymagazine.com](http://www.algaeindustrymagazine.com)

Spirulina honey

[www.spirulina.sg/Spirulina_Honey.html](http://www.spirulina.sg/Spirulina_Honey.html)

Food ingredients

SPIRULINA COLOR INGREDIENT

Net weight: 500 g.
Origin: Spain
3,15€

www.spirulina.sg/Spirulina_Beer.html

MICROLIFE

Microlife among the winner of Premio del Gusto 2012

Pastaria

The article about Microlife Pasta with Spirulina appeared on Pastaria, landmark magazine of the Italian pasta industry, which tells how Microlife also won the prestigious Premio del Gusto 2012. To the great interest that is mounting the world today in terms of biodesign and food products at 0 km, also the world of pasta making is putting a lot of attention on these topics.

www.microlife.bio
48,00€

www.microlife.bio
Food supplements

SPIRULINA + CHLORELLA + DUNALIELLA

Dr. Peter Hartig
www.dr-peterhartig.de/power-22

49,99€

www.nowfoods.com

29.99 / 25.85€

www.e21usa.com

60 Count Bottle - $39.95 / 34.44€

$49,95 / 37,80€

www.greensplus.com

360 capsules: $44.95 / 31,18€

240g: $25,95 / 17,99€

267g: $34,95 / 24,23€

www.nourishinghub.com.au

Powder: $49.95 / 37,80€
Caps (each 596 mg): $61,55 / 46,60

www.agmfoods.com

150g Powder - $82.95 / 71.51€
Food supplements

**DUNALIELLA**

- **ETHICAL NUTRIENTS**
  - www.ethicalnutrients.com.au
  - 60 caps: $28.90 / 21.84€; 180 caps: $69.30 / 52.37€

- **NIKKEN SOHONSHA CORPORATION**
  - www.nikken-miho.com/index_ecat.php?cPath=2
  - 498.56€

- **THOMPSONS**
  - www.thompsonsnutrition.com.au
  - 60 caps: $28.90 / 21.84€; 180 caps: $69.30 / 52.37€
Food supplements

**SPIRULINA**

- $22.55
- www.sunchlorella.com
- £21.59 / 907g

**CHLORELLA + DUNALIELLA**

- 5 oz (142g): 12 - $39.95 / 28.20€
- 2.5 oz (354g): 30 - $68.95 / 48.68€

**ASTAXANTHIN**

- Price range: $49.90 - $59.90
- www.astasupreme.co.nz
Nutraceuticals and health food

50% BETAGLUCAN = 25-35 US$/Kg

Spirulina platensis
Spirulina platensis de elevada calidad, cultivada bajo condiciones controladas, libre de conservantes, aditivos o colorantes.

<table>
<thead>
<tr>
<th>Nutrient Value (per 100 g)</th>
<th>Protein</th>
<th>Carbohydrates</th>
<th>Fat</th>
<th>Ashes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15-70 g</td>
<td>10-100 g</td>
<td>1-3 g</td>
<td>1-7 g</td>
</tr>
</tbody>
</table>

15 € the 100 g pack
**algility™** Whole Algal Flour has been recognized at the FIE Innovation Awards 2013

Involved in the microalgae area for several years, Roquette has developed three new microalgae-based ingredients with nutritional and functional benefits for Nutrition, Health and Nutraceuticals.

**algility™ HL Whole Algal Flour:**
A whole food ingredient which significantly improves the nutritional qualities of recipes (reduces fat, optimizes lipid profile) while preserving taste and texture.

**algility™ HP Whole Algal Protein (†):**
A whole food ingredient, which combines plant-based proteins (as an alternative to animal proteins), fibers and unsaturated lipids.

**algility™ chlorella:**
A nutrient-rich whole food ingredient (proteins, antioxidants, vitamins and minerals) to boost the daily diet.
Cosmetics and cosmeceuticals

- Advanced Marine Biology
  - www.laprairieswitzerland.com
- Cellular Swiss Ice Crystal
- Repairwear Uplifting Firming Cream
  - www.clinique.com

AHAVA
- Spirulina
  - €24.95 - 250 ml
  - www.ahava.com

- Blue Green Algae
  - £7.69
  - www.aubreyorganicsuk.co.uk

Chlorella vulgaris Isochrysis galbana (T-ISO)
  - www.algaenergy.es
Cosmetics and cosmeceuticals

It was not until 2010 that the Salins group began to study the microorganisms on the Salins. The expert scientific team in valuation of microalgae will examine the case of Dunaliella salina, a species of salt-tolerant green algae (i.e., who copes well with high salt concentration environments).

Price range: 14€ - 65€
Agriculture growth promoters and fertilizers

SPIRULINA

www.algaenergy.es/

www.biorizon.es/Bioalgal_Marine/Algafert_Abonos_es.html
from production technology and product development to the MARKET
A4F has a very close relationship with the leading scientists and researchers in the field of microalgae biotechnologies, as well as with the largest microalgae producers, worldwide. Therefore, A4F is a **first choice** for any large-scale contract as the best specialist company in almost every specific aspects of microalgae production with the most extended knowledge network.

from production technology and product development to the MARKET
As a global company, A4F collaborate in R&D European projects and offer our consultancy services in Europe (Portugal, Spain, France, UK, the Netherlands, Germany), in the Middle East (Saudi Arabia), South America, and wherever our clients are.

While being a company involved in many activities within microalgae cultivation, both in R&D and in implementation of industrial production units, A4F also helps the clients in the development of the final products, including the biorefinery concept.

from production technology and product development to the market
## R&D PROJECTS: our background for providing state-of-the-art services

<table>
<thead>
<tr>
<th>Program</th>
<th>Acronym</th>
<th>Topic</th>
<th>Start date</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GIAVAP</td>
<td>Genetic modification of marine or freshwater algae to better suit industrial applications</td>
<td>2010Nov</td>
<td>36 months</td>
</tr>
<tr>
<td></td>
<td>BIOFAT</td>
<td>Biofuels from microalgae</td>
<td>2011Apr</td>
<td>48 months</td>
</tr>
<tr>
<td></td>
<td>ALGAPLEX</td>
<td>Mixotrophic microalgae growth</td>
<td>2009Oct</td>
<td>24 months</td>
</tr>
<tr>
<td></td>
<td>DEMA</td>
<td>Direct bioethanol from microalgae</td>
<td>2012Dec</td>
<td>54 months</td>
</tr>
<tr>
<td></td>
<td>PHOTO.COMM</td>
<td>Photosynthetic communities in industrial cultivation</td>
<td>2012Oct</td>
<td>48 months</td>
</tr>
<tr>
<td></td>
<td>ProEcoWine</td>
<td>Plant protection products from microalgae</td>
<td>2012Nov</td>
<td>24 months</td>
</tr>
<tr>
<td></td>
<td>D-Factory</td>
<td>Cultivation and biorefinery for <em>Dunaliella</em></td>
<td>2013Dec</td>
<td>48 months</td>
</tr>
<tr>
<td></td>
<td>PUFAChain</td>
<td>Developing a pipeline of PUFA-derived products from several species of microalgae</td>
<td>2013Nov</td>
<td>48 months</td>
</tr>
<tr>
<td></td>
<td>ALFF</td>
<td>The Algal Microbiome Friends and Foes</td>
<td>2014Dec</td>
<td>48 months</td>
</tr>
<tr>
<td></td>
<td>PHOTOFUEL</td>
<td>Stimulating the innovation potential of SMEs for a low carbon energy system.</td>
<td>2015Jul</td>
<td>48 months</td>
</tr>
</tbody>
</table>
• Production conditions optimization of freshwater and marine microalgae
  • *Chlorella, Haematococcus, Nannochloropsis, Dunaliella, Phaeodactylum, Spirulina, Synechocystis, Thalassiosira, Scotielopsis, Chlamydomonas* ….
• GMO and non-GMO
• Water and nutritive medium management/optimization
• Culture medium treatment and recycling optimization
• Cultivation systems custom engineering
• Biomass harvesting and processing
• Training in PBR, GW and CRW operation

from production technology and product development to the market
LISBON
INNOVATION
LABORATORY
LIL
Mission

• A4F’s LIL is fully equipped to support R&D activities. It houses A4F’s microalgae culture collection, culture collection bank (backups and inocula improvement programs for production units) and hosts R&D experimental projects and analysis in supporting pilot scale and industrial production units.

Research activities

• Cultivation and Scale-up (GMO certification)
• Analytical Biochemistry
• Molecular Biology
• Bright field and Fluorescence Microscopy
Culture collection

- A4F’s Culture Collection includes close to **100 strains** of microalgae and cyanobacteria on site and privileged access to more than **1200 isolates** through partnerships and contracts.
- Microalgae are isolated from sites of interest or acquired for clients, R&D projects, biotechnology development.
Support services

• External market study of microalgae for food and feed applications
• Develop a detailed and final Business Case for the industrial production unit
• Industrial production unit engineering design and construction
all started with a prototype, a pilot and then large-scale
LiMBAC

2nd Edition will give a larger emphasis to pilot plant cultivation techniques

13th to 18th November 2016
www.limbac.com

1st edition LiMBAC - Lisbon, in 2013:
• Attracted 50 participants from 23 countries, with an average age of 32;
• A very interactive programme, participants from 18 companies and 17 Universities;
• Focused largely on lectures about case studies of microalgae businesses;
• Practical Lab sessions about isolation, cultivation;
• Biochemical analysis of microalgae cultures.

Venue: A4F, Algae For Future, SA
Campus do Lumiar - Edifício E, r/c Estrada do Paço do Lumiar 1049-038 Lisboa, Portugal
Phone: +351 218072499
Website: www.a4f.pt
More information: tiago.guerra@a4f.pt

Fees and Registration
The course fee is 800 € (for students) and 1600 € (for non-students)
It includes the course and all supporting material, daily commutes between A4F and hotel, coffee breaks, lunches and one conference dinner

Accommodation
Discount rates for hotel accommodation will be announced shortly.

2nd edition LiMBAC
Lisbon, 13th to 18th November 2016

The 2nd edition of the LiMBAC aims to familiarize participants with advanced concepts of microalgae cultivation with a special attention to scale-up processes, large scale cultivation and downstream processing. The course will take an interdisciplinary approach, presenting lectures covering the whole microalgae value chain as well as lab and pilot plant practical sections where participants will have hands-on experience in culturing microalgae. The course is targeted to participants with some background and experience in the microalgae field.
Thank you!

Vítor Verdelho with special thanks to Joana Lapa

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