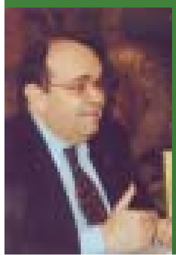
The combined valorization of bio-products and byproducts; the cases of micro algae production and glycerol conversion.



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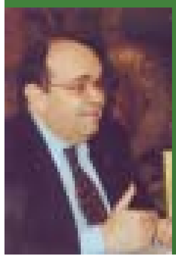
Common problems

- The high value products and by-products have a limited market
- A large supply can strongly decrease the price
  - The large amounts of glycerol from biodiesel production have saturated the market jet
  - The algae on the market can already cover the requirements



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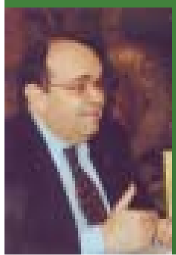
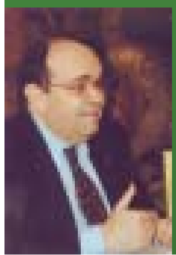
The markets

- The energy market is infinite…
  - The competition is not with the oil costs (that are increasing, and will increase even more), but with biofuels; the prices come out the legal costrains
- Animal feed
  - The market is wide, but the presence of large amounts of new products can distort it



Glycerol

- Our experience comes out the production of hydrogen
- With selected bacterial population, the production is among the highest obtained in the world
- But still we convert 20% of the energy content in gas
- The rest are ethanol and fatty acids, plus a small percent of internal use
- The test show a very stable process, also with glycerol of different sources



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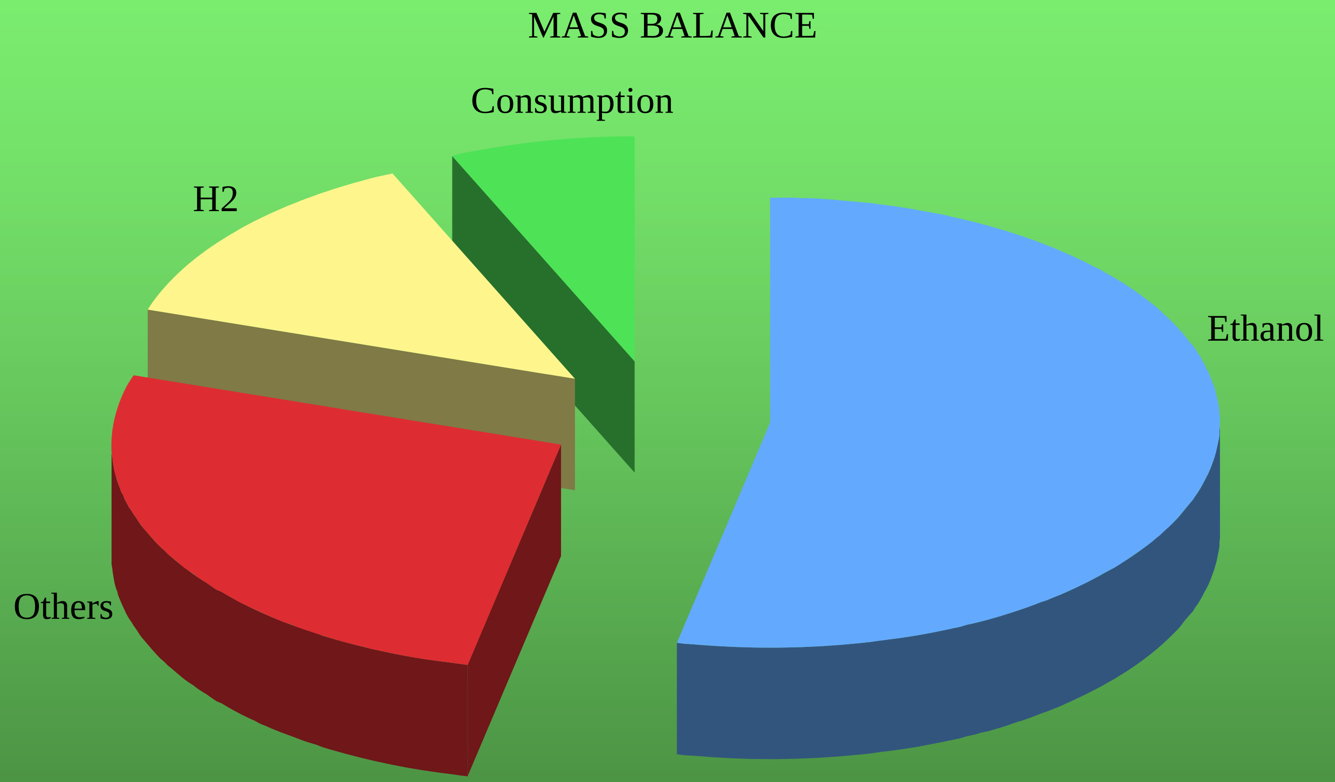
Glycerol conversion - mass balance



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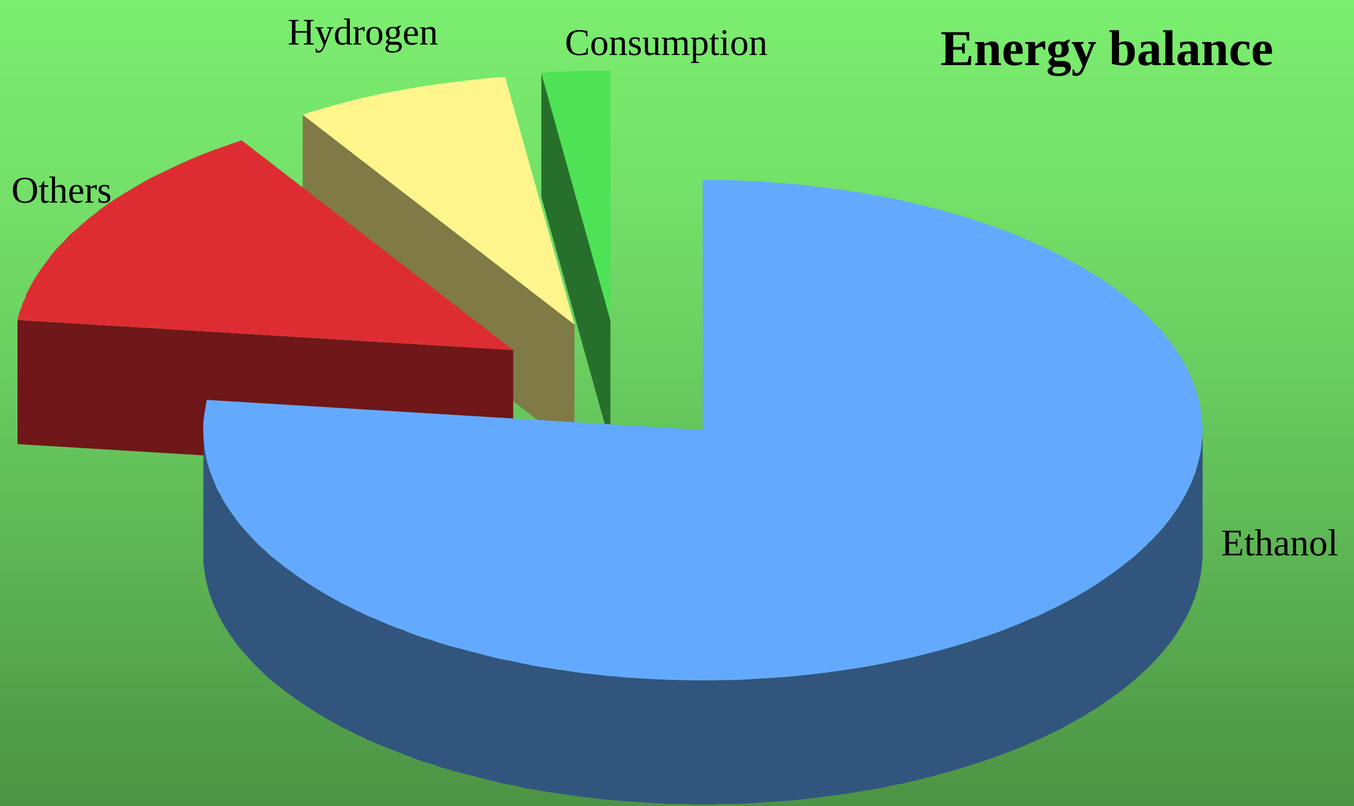
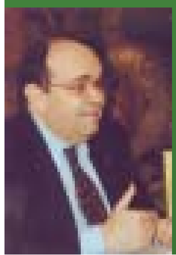
Glycerol





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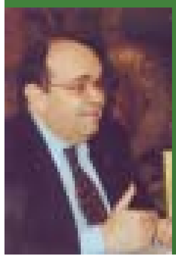
Glycerol conversion

- The addition of ethanol increases the quality of biodiesel
- The value of ethanol covers all the transformation costs, with economic advantage
- The H_2, if we do not want to store or sell, can be directly converted into energy, for the plant supply and the grid
- The fatty acids can be converted into methane, supplying energy to the system



Glycerol

- What are we doing now?
- Experiences are on batch scale
- The results are interesting, but we are sure that productions can increase
- We will build up a continuous reactor, in order to verify the feasibility of industrial plants
- Thanks to Cristiano Varrone

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Algae

- The composition of algae is very variable
- Only the use of all the matter can give economics
- Otherwise it become waste…

- The example of Venice

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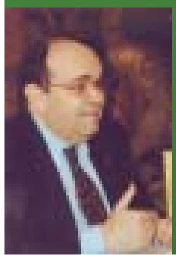
Algae of Venice

- They are macroalgae (Ulva rigida)
  - From the XIX century people tried to get cellulose out of algae in order to produce paper
  - Paper is a mixture of cellulose, starch and minerals
  - Exactly as algae…
  - Then “Alga carta”



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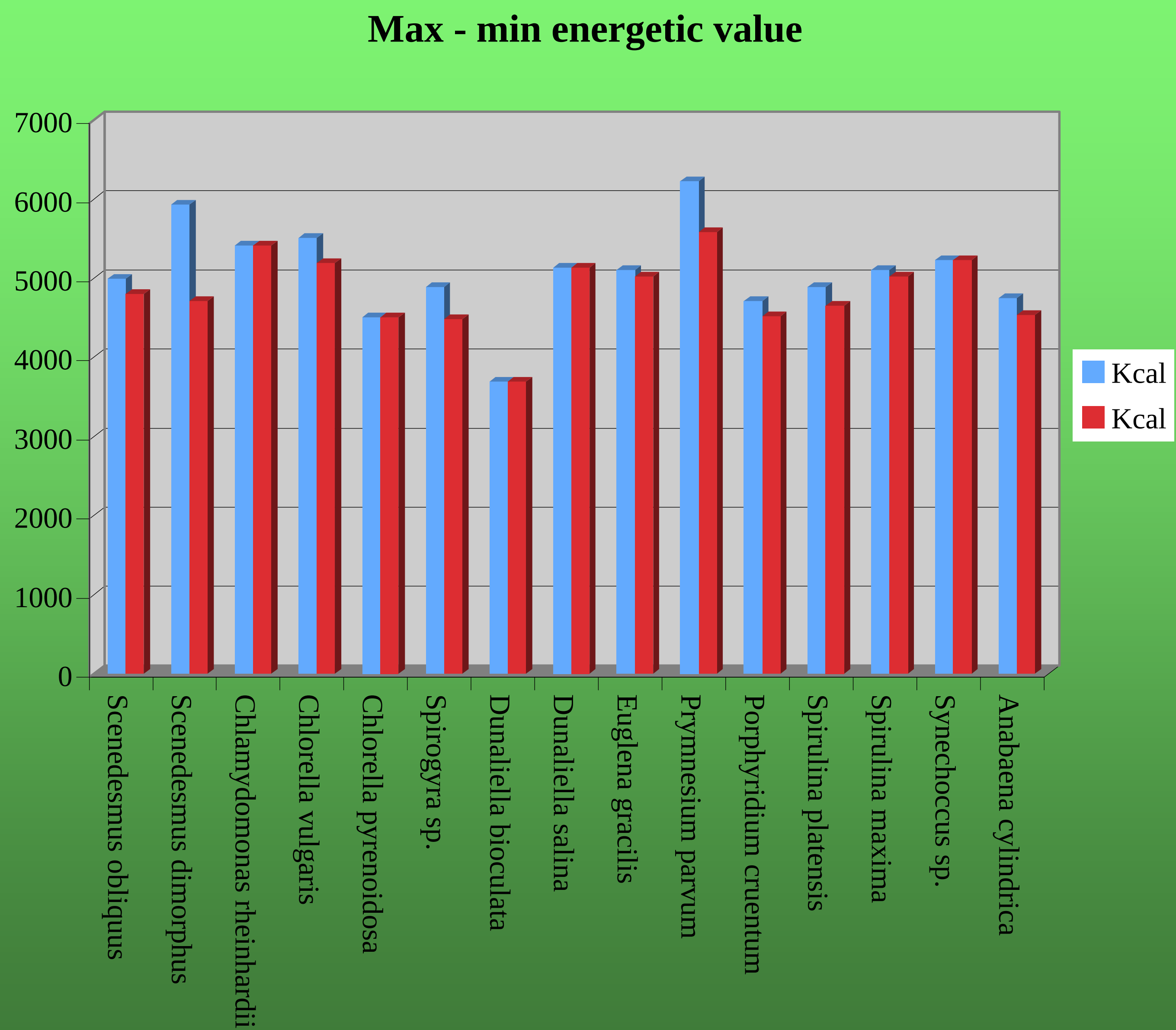
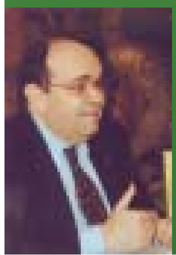
Heath value algae kCal/kg





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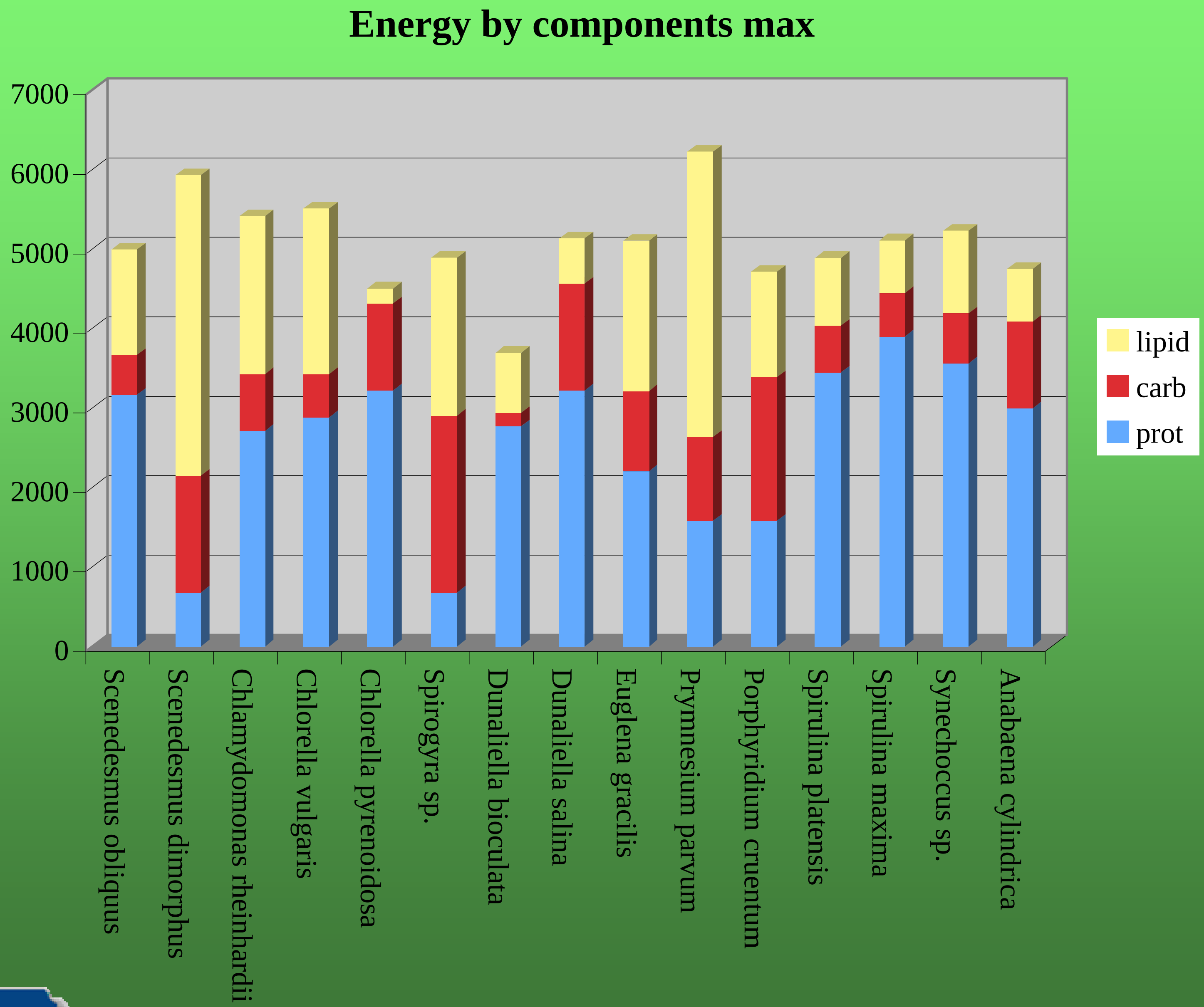
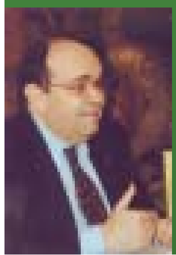
Microalgae energy max kCal/kg





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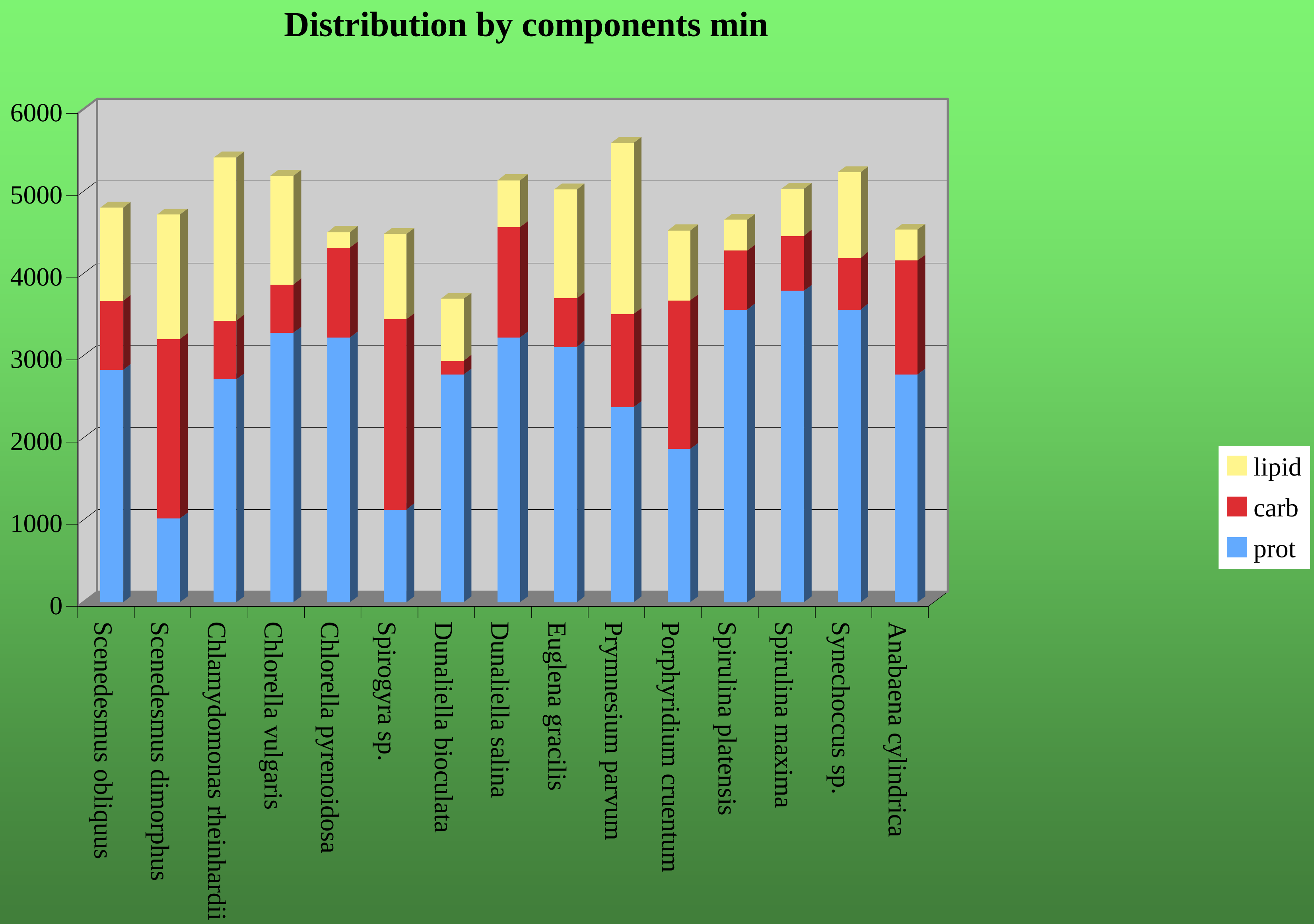
Microalgae energy min kCal/kg



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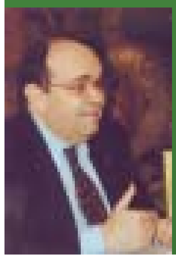
Results with N starving

- + 40% lipids
- - 30% production
- In all cases (algae stream) less energy
- Almost 10% less energy

•Prymnesium parvum= 5167 kCal with starving, 5586 kCal without starving, minus 418 kCal



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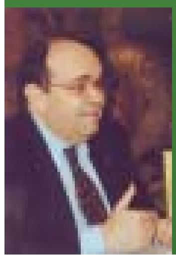
Need increase yield

- Concerning energy: increase in lipids are interesting if the total weight increases
- Otherwise we do not gain value
- The example of mais silage
- We must find out systems for the increase of total production
- Test on **real scale plants** with different streams, in different conditions
- Real scale tests with continuous reactors for define value of starving



What to do with proteins?

- Animal feed, is usually the answer
- But if the market suggests different solutions
- We must convert it into energy
- New researches ongoing
- Bacteria converting proteins into carbohydrates
- Research in our laboratories

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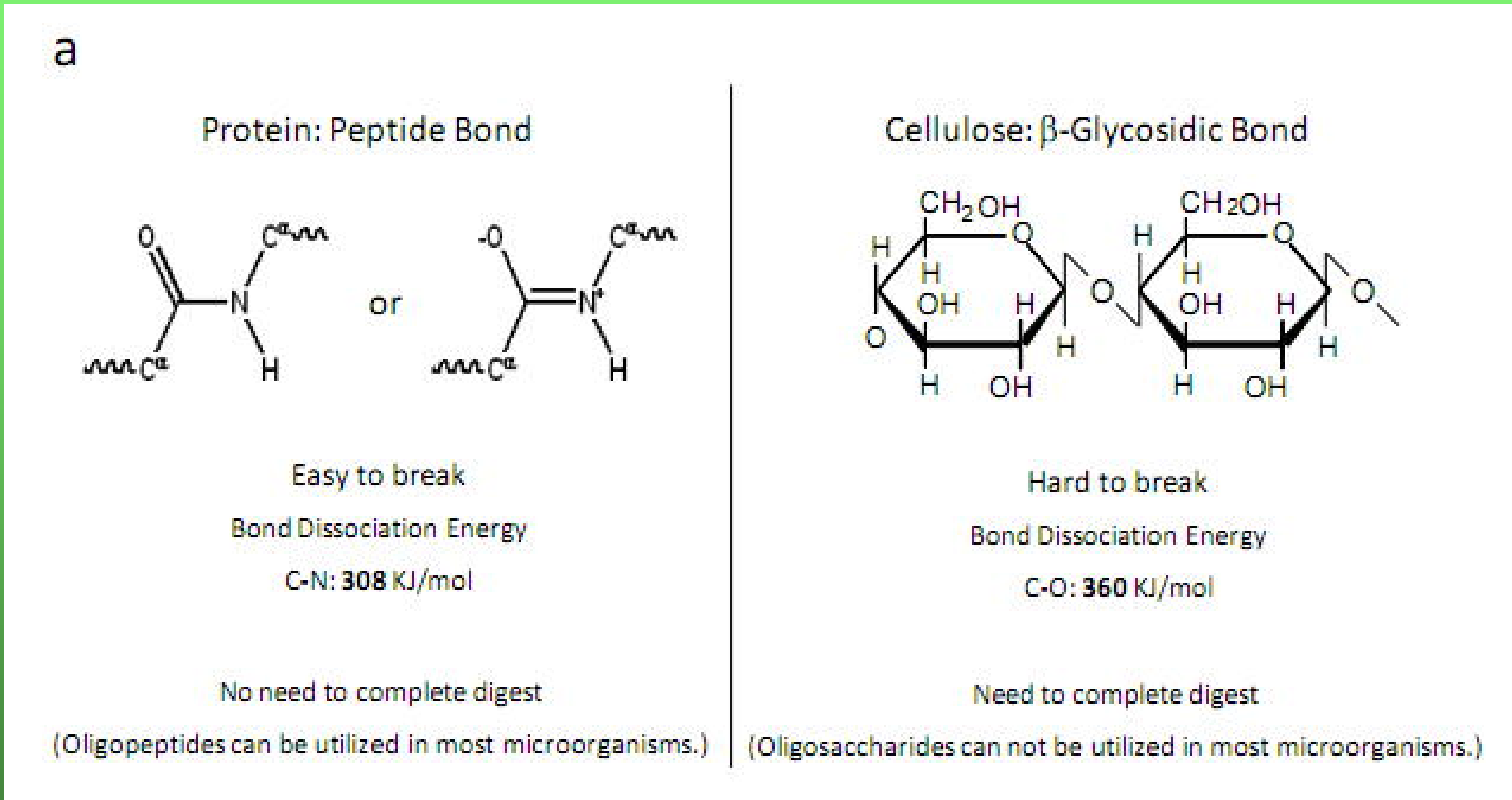
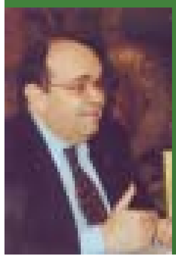
Protein to energy





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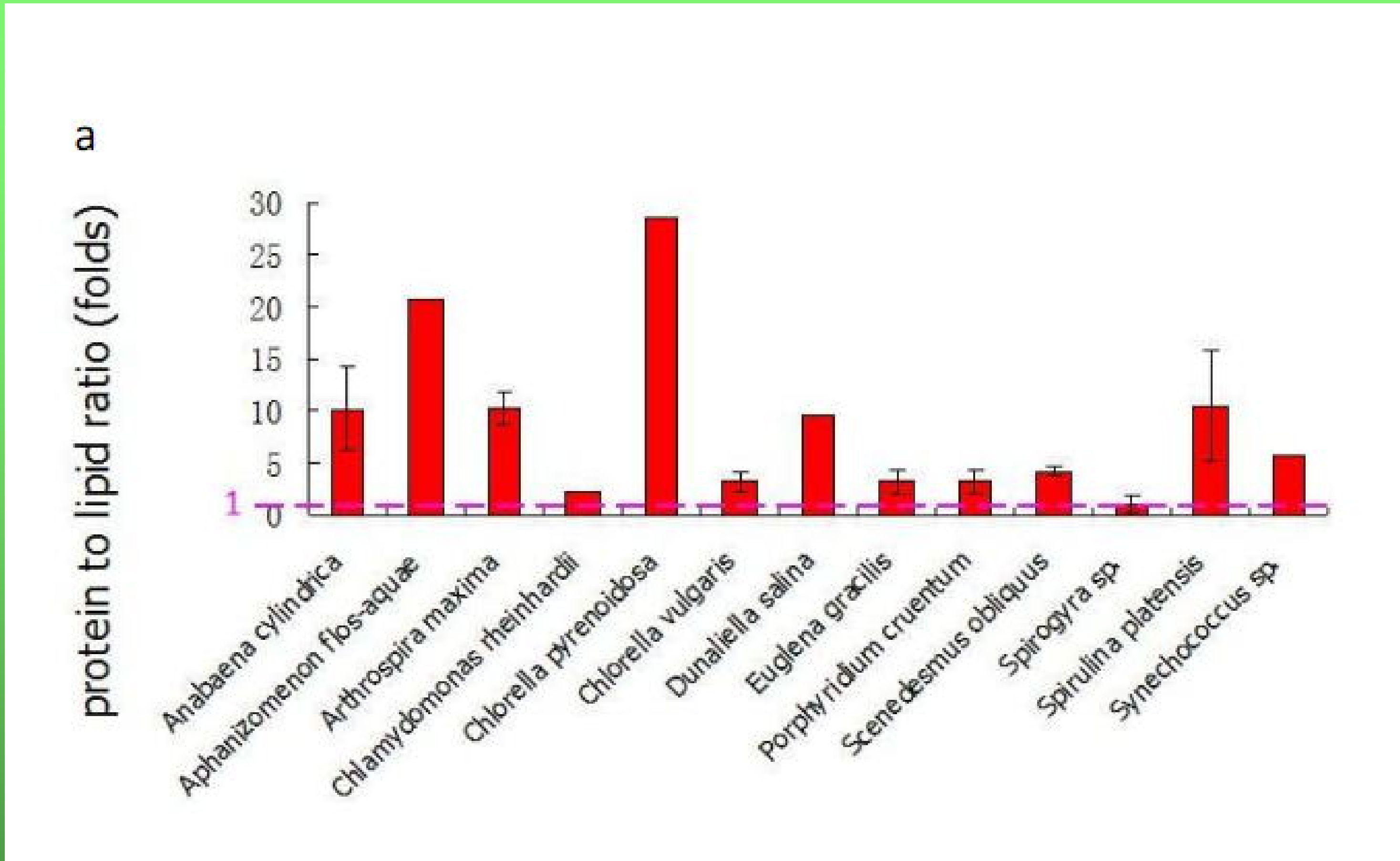
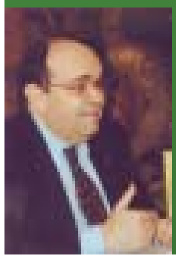
Protein/lipid ratio



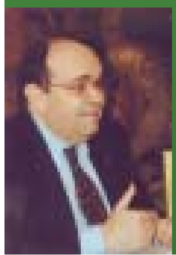
Conversion of proteins into biofuels by engineering nitrogen flux, Yi-Xin Huo, Kwang Myung Cho, Jimmy G Lafontaine Rivera, Emma Monte, Claire R Shen, Yajun Yan & James C Liao

Nature Biotechnology (2011)



Future photobioreactors

- High efficiency
- Low capital cost
- Low energy consumption
- Resolution to the major problems:
  – mixing
  – harvesting
  – temperature
- Following what was done in the past…



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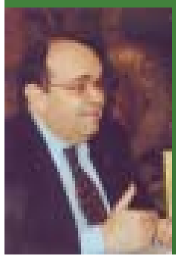
Photobioreactors, 1979



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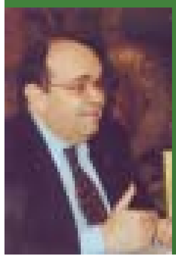
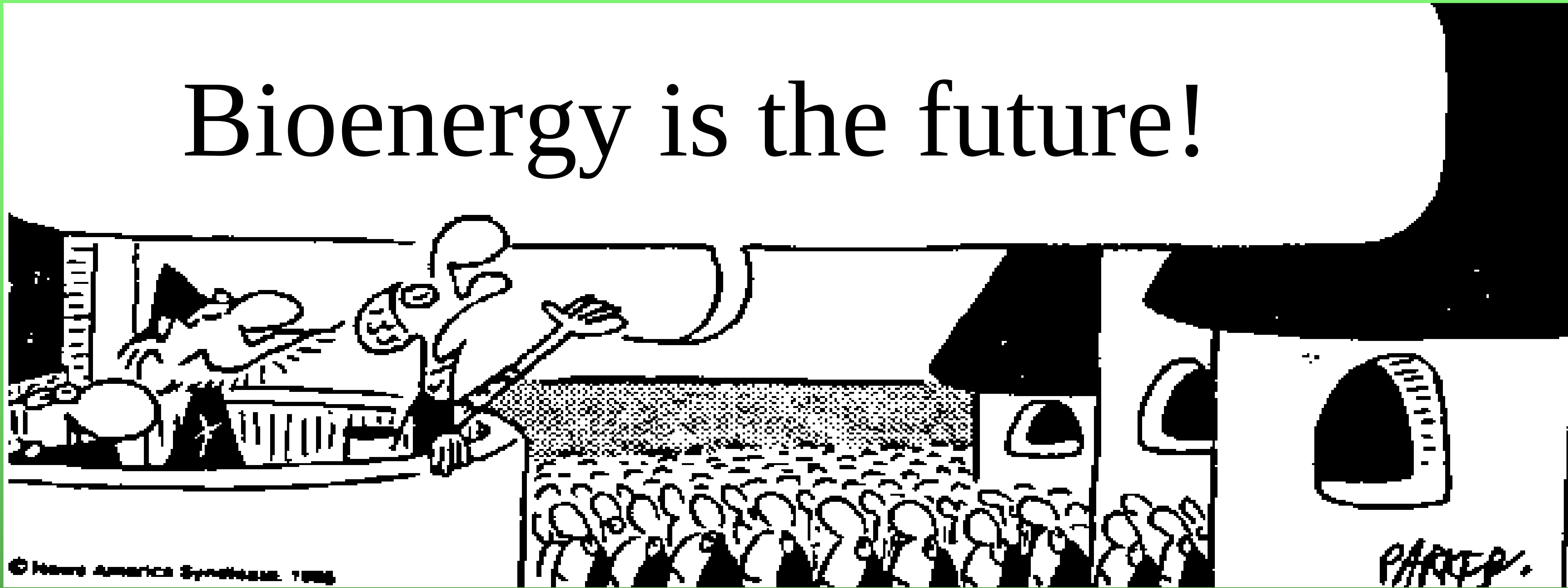
Researches going on

- Continuous reactor for glycerol conversion
- Protein to energy conversion
- New photo-bioreactor technology, for testing the real efficiency of the system





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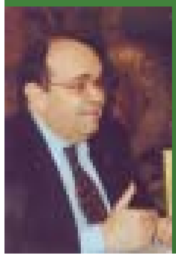

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