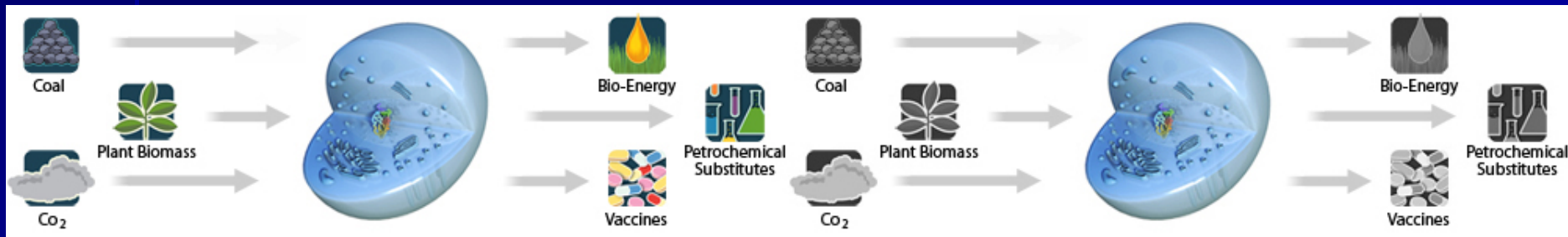


Everybody wants microalgae...

- GM microalgae are expected soon, since this is the expertise of Synthetic Genomics
- Possibly cyanobacteria and green algae are the first choice groups



Everybody wants microalgae...

- An unusual experiment featuring equal parts science, environmental optimism and **Native American capitalist ambition** is unfolding here on the Southern **Ute Indian Reservation** in southwest Colorado.
- With the twin goals of making fuel from algae and reducing emissions of heat-trapping gases, a start-up company co-founded by a Colorado State University professor recently introduced a strain of algae that loves carbon dioxide into a water tank next to a natural gas processing plant. The water is already green-tinged with life.



They are not *yanomamis*...

- <http://www.southern-ute.nsn.us/>



Everybody wants microalgae...



>>

A screenshot of the Sapphire Energy website. The header includes the Sapphire Energy logo and navigation links for "News & Media", "Careers", and "Contact". Below the header are two tabs: "THE COMPANY" and "THE PRODUCT". The main content area features a large image of green microalgae cells with the text "sunlight + CO₂ + sapphire = renewable gasoline". To the right of the image is a text block: "Sapphire Energy's revolutionary platform has harnessed advances in science and technology to produce the world's first renewable gasoline. Not biodiesel. Not ethanol. Clean, green crude oil." Below this are three columns of content: "company news" with links for "ALTERNATIVE ENERGY PRODUCER", "SAPPHIRE ENERGY APPLAUDS", and "STIMULUS BILL PASSAGE February 17, 2009"; "events" with a link for "San Diego Science Festival 2009"; and "Green Crude Production" with a link for "Find out more". The footer contains the copyright notice "© 2008 Sapphire Energy. All rights reserved."

Everybody wants microalgae...



Carlos Slims, Mexico



Bill Gates, USA



Eike Batista, Brazil

Everybody wants microalgae...

- Brazil's state oil company Petrobras has announced plans to make investments in microalgae cultivation in Brazil
- However, numbers and dates have not yet been announced
- There are expectations of huge investments, following other international oil companies




There are many international symposia on microalgal biofuels



Discover the art & science of converting the Sun's energy to Oil at
Algae Biofuel Summit 2008
Announcing the Arrival of Next Generation Biofuels

Hosted by



17th, 18th & 19th September 2008, New Delhi, India



ICAO WORKSHOP



AVIATION AND ALTERNATIVE FUELS

ICAO Headquarters,
Montréal, Canada, 10 to 12 February 2009

ALGAE BIOFUELS

World Summit

What constraints the large-scale microalgae production?

- High cost of production
- Low efficiency of harvesting
- Losses in the conversion of biomass into biofuels
- Diseases and contamination
- Water
- Science
- Heavy investments for a highly biotechnological production



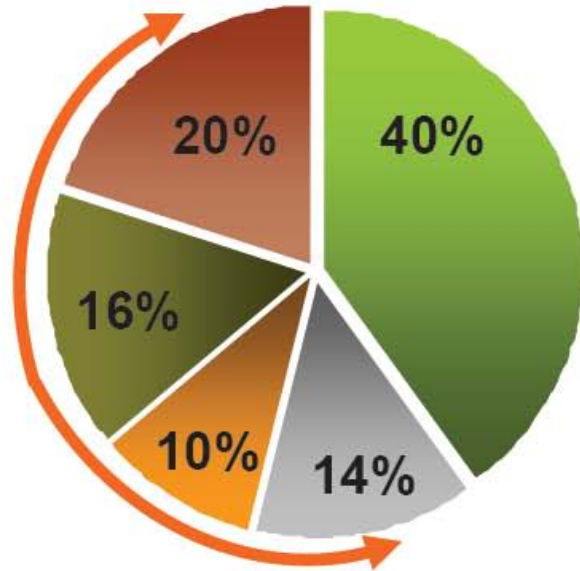
Researcher Mike Latz swirls bioluminescent dinoflagellates into action. Find out more at siobiolum.ucsd.edu

- We have to put more light in microalgal cultivation!

What constraints the large-scale microalgae production?



What constraints the large-scale microalgae production?



- Algal culture
- Harvesting/dewatering
- Drying
- Oil extraction
- Oil conversion



Civil aviation – search for alternative biofuels

Flight from London to Amsterdam, February 24th, 2008, Virgin Atlantic. Jet-fuel produced with a mixture of vegetable oils.

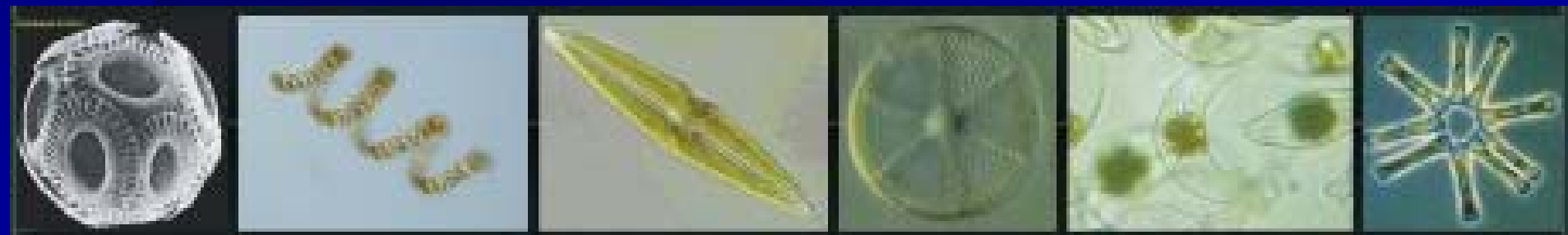


» **AVIÃO VERDE**
O empresário Richard Branson posa no aeroporto de Heathrow, em Londres, em frente a Boeing-747 antes do primeiro voo de teste de sua companhia, a Virgin Atlantic, com biocombustível, feito de óleo de babaçu e de coco; o jato foi até Schiphol (Amsterdã)

Flight around Huston, Texas, USA, January 7th, 2009, Continental Airlines. Jet-fuel produced with a mixture of jatropha and microalgae. Japan Air Lines performed a similar flight on January 30th, around Tokyo.



Brazil is one of the countries that gather best conditions in world to run large-scale projects on microalgal production



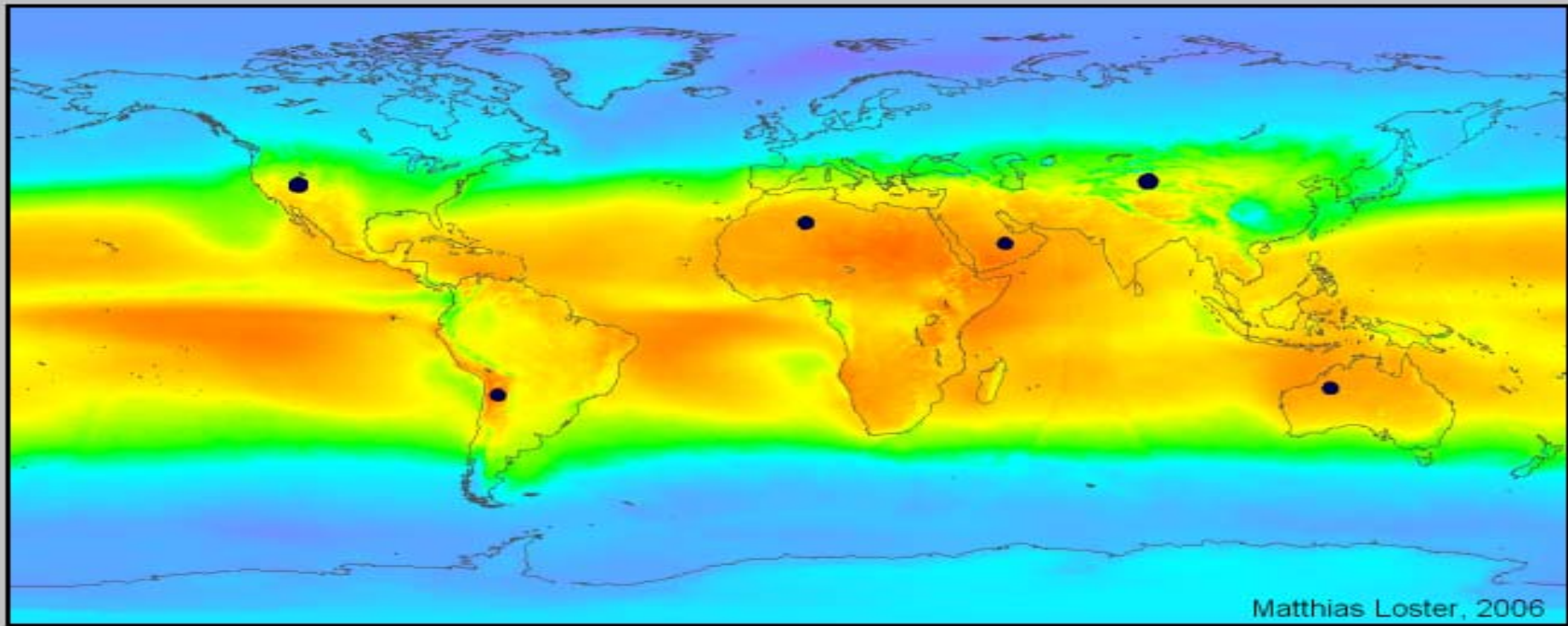
Geographic data



- Brazil is the fifth largest country in the world, with 8,547,404 km², and has the fifth population in the world, with 189,460,000 inhabitants (IBGE, 2007)
- 26 states and 1 federal district.
- 80% of the Brazilian population are along the coastline (ca. 145 million inhabitants).
- High biodiversity, including huge ecosystems, such as Amazon Forest, Pantanal (wetlands), Cerrado (a Brazilian savannah), tropical and sub-tropical oceanographic domains.

Solar energy in Brazil

- Excellent sites to build microalgal facilities
- 50% of the PAR is distributed above 700 nm (150 W/m^2) – ideal $140 > \text{PAR}$; most of the USA has PAR below 90 W/m^2 (the maximum in the USA is 105 W/m^2 in part of the southern states)



$\Sigma \bullet = 18 \text{ TWe}$

Many suitable places in Brazil are poor, and have no conflict with other uses

- Vast areas in Brazil are under desertification and the soil is unsuitable for agriculture
- Most of these areas have low human occupation and low family income
- There are lots of underground water!
- Very low precipitation



It is necessary to invest in culture collections

- Possibly Petrobras will finance a large culture collection at Universidade Federal Fluminense
- This would support Brazil's progress in this field in the future



Distribution of culture collections in Brazil

Nova Hedwigia 79 1—2 149—173 Stuttgart, August 2004

Culture collections of microalgae in Brazil: progress and constraints*

by

Sergio O. Lourenço** and Armando A.H. Vieira²

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With 2 figures and 1 table

Lourenço, S.O. & A.A.H. Vieira (2004): Culture collections of microalgae in Brazil: progress and constraints. - Nova Hedwigia 79: 149-173.

Abstract: Almost 30 years after the foundation of the first culture collection, there are currently 37 laboratories and institutions where cultures of microalgae (including cyanobacteria) are kept in Brazil. In addition, there are three culture collections of macroalgae in the country. Most of these collections hold small numbers of strains, and only five of them have more than 150 strains. An increasing interest in microalgal cultures has been experienced in Brazil, especially due to the development of aquaculture, use of algae in ecotoxicity tests, and monitoring of harmful algal blooms. In addition, the provision of financial support by governmental agencies has stimulated the growth of aquatic sciences, including uses and applications of cultivation of microalgae. The continental dimension and variety of environments in Brazil mean that there is an enormous microalgal biodiversity to be assessed, especially in freshwater habitats. Brazilian culture collections are concentrated in the South and Southeast regions of the country and mainly hold local strains. Efforts must be done to create culture collections in other regions and a network of researchers to isolate and cultivate strains from different parts of the country. The ongoing expansion of the Elizabeth Aidar Microalgal Culture Collection, Federal Fluminense University, represents the start of the organization of a national reference center for cultivation of marine microalgae.

Introduction

Cultivation of microalgae has a history of a little more than a century and followed the development of microbiology, physiology, and environmental sciences (Gonzalez

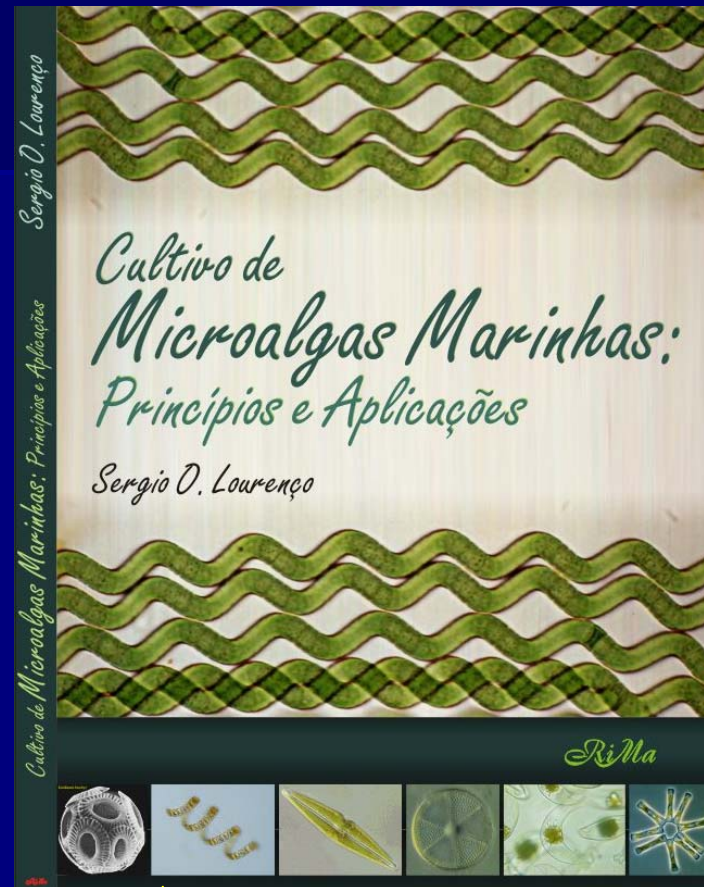
*This paper is dedicated to the memory of Dr Édison J. de Paula, who died on 21 September 2003. Dr Paula was a very enthusiastic researcher on cultivation of seaweeds in Brazil.

DOI: 10.1127/0029-5035/2004/0079-0149

0029-5035/04/0079-0149 \$ 6.25

© 2004 J. Cramer in der Gebrüder Borntraeger
Verlagsbuchhandlung, D-14129 Berlin · D-70176 Stuttgart

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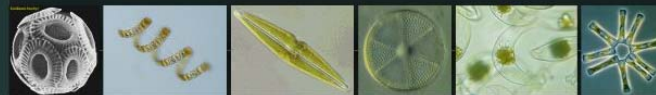
Sergio O. Lourenço

Cultivo de Microalgas Marinhas: Princípios e Aplicações

Cultivo de Microalgas Marinhas: Princípios e Aplicações

Sergio O. Lourenço

RiMa



↑
Lourenço (2006)

← Lourenço & Vieira (2004), Nova Hedwigia



Sergio de Oliveira Lourenço nasceu no Rio de Janeiro em 1970. Graduiu-se em Ciências Biológicas (licenciatura) na Universidade Federal Rural do Rio de Janeiro (1987-1991) e cursou doutorado em Oceanografia Biológica na Universidade de São Paulo (1992-1996). Realizou estágio de pós-doutorado em Queen's University of Belfast, Irlanda do Norte (Reino Unido), conduzindo pesquisas sobre fisiologia de algas (2000-2002). É professor adjunto da Universidade Federal Fluminense (UFF, Niterói, RJ), estando lotado no Departamento de Biologia Marinha desde dezembro de 2004. Antes, atuou como bolsista recém-doutor na Universidade Federal do Rio de Janeiro (1997-1999) e na própria UFF, como bolsista, em duas ocasiões: com apoio da FAPERJ, bolsa de Fixação de Pesquisador (1999-2000), e com apoio do CNPq, bolsa PROFIX (2002-2004).

Seu interesse por cultivo de microalgas foi despertado no final da graduação e motivou a realização de doutorado desenvolvendo uma tese na especialidade, sob a orientação da Profa. Dra. Elizabeth Aidar. Suas pesquisas enfocam principalmente estudos sobre a composição química de microalgas em cultivo, alimentação de larvas de bivalves com microalgas e composição química de algas

Distribution of culture collections in Brazil



- Culture collections are indicated as red asterisks.
- Most of them are located in Southeastern and Southern regions, holding mainly local isolates.
- Only five culture collections have more than 150 strains.
- Three culture collections are dedicated exclusively to cyanobacteria.

The cultivation of microalgae in Brazil - recent progress

- In 2008, a public call was organized by National Council for the Development of Science and Technology (CNPq) to stimulate research on microalgae for biofuels
- 63 groups applied
- The national committee (coordinated by this speaker) selected 15 proposals to share R\$ 6.5 million (2008-2010)
- Groups will work on cultivation systems, advanced techniques of cultivation, harvesting and strain selection
- An integration of the actions is expected in the near future
- **Petrobras is also supporting some key large projects**



Brazilian teams are networking

In Brazil, the focus is on microalgal biomass production



- The Brazilian teams met recently (October 14-17th) in Natal to discuss the progress and plan next activities

Brazilian teams are networking

- Brazil has *ca.* 80 research groups on microalgae production to generate biofuels
- There are 200 PhD researchers, 80 MSc researchers and 350 graduated and undergraduate students countrywide involved with this subject



Brazilian teams are networking

Development of photobioreactors

- 9 groups – Salvador (2), Curitiba (2), Rio de Janeiro (3), Rio Grande, Pelotas

Cultivation in shallow ponds

- 14 groups – Natal, Florianópolis (2), Rio de Janeiro (2), Rio Grande (2), Porto Alegre, São Carlos, Parnaíba, Ilhéus, Goiânia, Piracicaba, Niterói

Chemical characterization of microalgal biofuels

- 12 groups – Natal, Florianópolis, Rio de Janeiro (2), Rio Grande (2), Pelotas, São Carlos, Goiânia, Piracicaba, Niterói, Salvador

Growth of Science in general in Brazil

- Brazil has been experiencing a remarkable scientific development since the early 1990's.
- Scienciomtric data: Brazil is currently responsible for 2.1% of world scientific production (CAPES, 2009).
- By comparison, in 1982 the Brazilian contribution was only 0.28% of the world scientific production and 0.57% in 1993 (Meis & Leta, 1996).
- This outstanding progress of the scientific contributions of Brazil has been intensifying since the mid 1990's.
- Expansion of the Brazilian graduate system – 16,000 Ph.D. a year by 2010 (11,700 in 2008)
- (Promise) of expanding the investiment in Science to 2% by 2010 (1,1% in 2001)
- Brazil never has invested so much in Science as it does now



Growth of Science in general in Brazil

- Access to information

- Portal Periódicos CAPES – more than 15,400 journals
- Scientific Electronic Library on Line – SciELO



- Creating tradition in Biotechnology, Marine Sciences and Engineering
- Role of scientific associations and congresses
 - Brazilian Society of Phycology
 - Brazilian Association of Marine Biology
 - Brazilian Society of Chemical Engineering
 - And many others

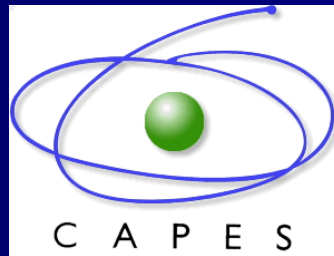
Microalgae cultivation is really growing in Brazil

- A major challenge is the integration and coordination of the actions to get a greater and faster development
- It is necessary to stimulate private companies



*Simpósio Brasileiro
do Potencial Energético
das Microalgas*

2009



C A P E S



O BANCO DO DESENVOLVIMENTO
DE TODOS OS BRASILEIROS



FINANCIADORA DE ESTUDOS E PROJETOS
MINISTÉRIO DA CIÊNCIA E TECNOLOGIA



Universidade
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Fluminense

2008

seminário fluminense de
BIOCOMBUSTÍVEIS E BIOMASSA



Some concluding remarks

- It is mandatory to diversify the matrix of biofuel production
- To put biokerosen in the agenda
- Microalgae are the most promising source for biodiesel and biokerosen
- In terms of research, probably no team will get full control of all steps of biofuel production from microalgae – focus is needed

Acknowledgements

- To the organizers of the Aquatic Biomass: Sustainable Bioenergy from Algae?
- To Klaus Hennenberg, Ursel Draude and Renato Morchio for their kind assistance to make the arrangements to my attendance at the workshop
- To the audience

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A view of Rio de Janeiro from UFF Campus