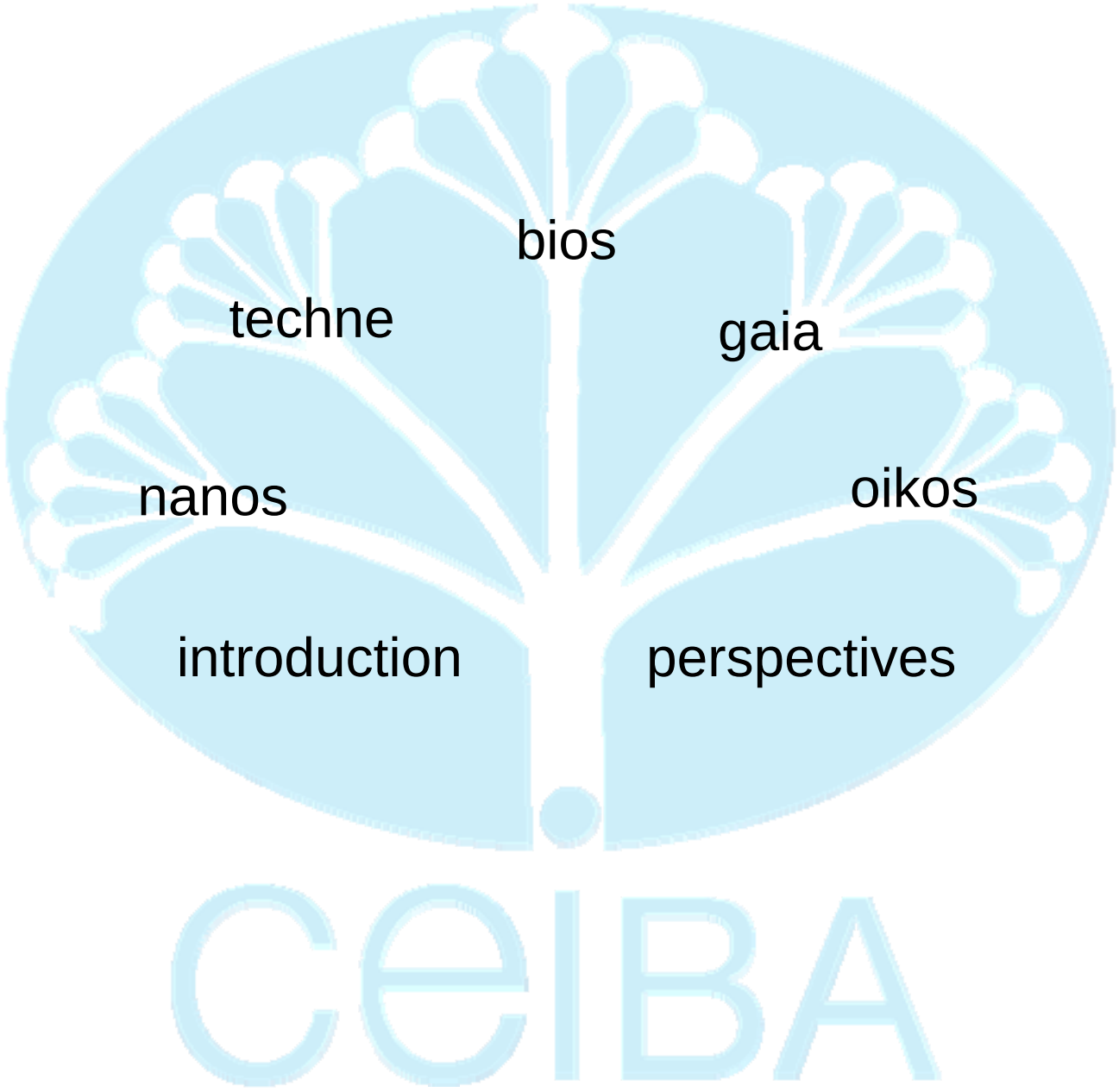
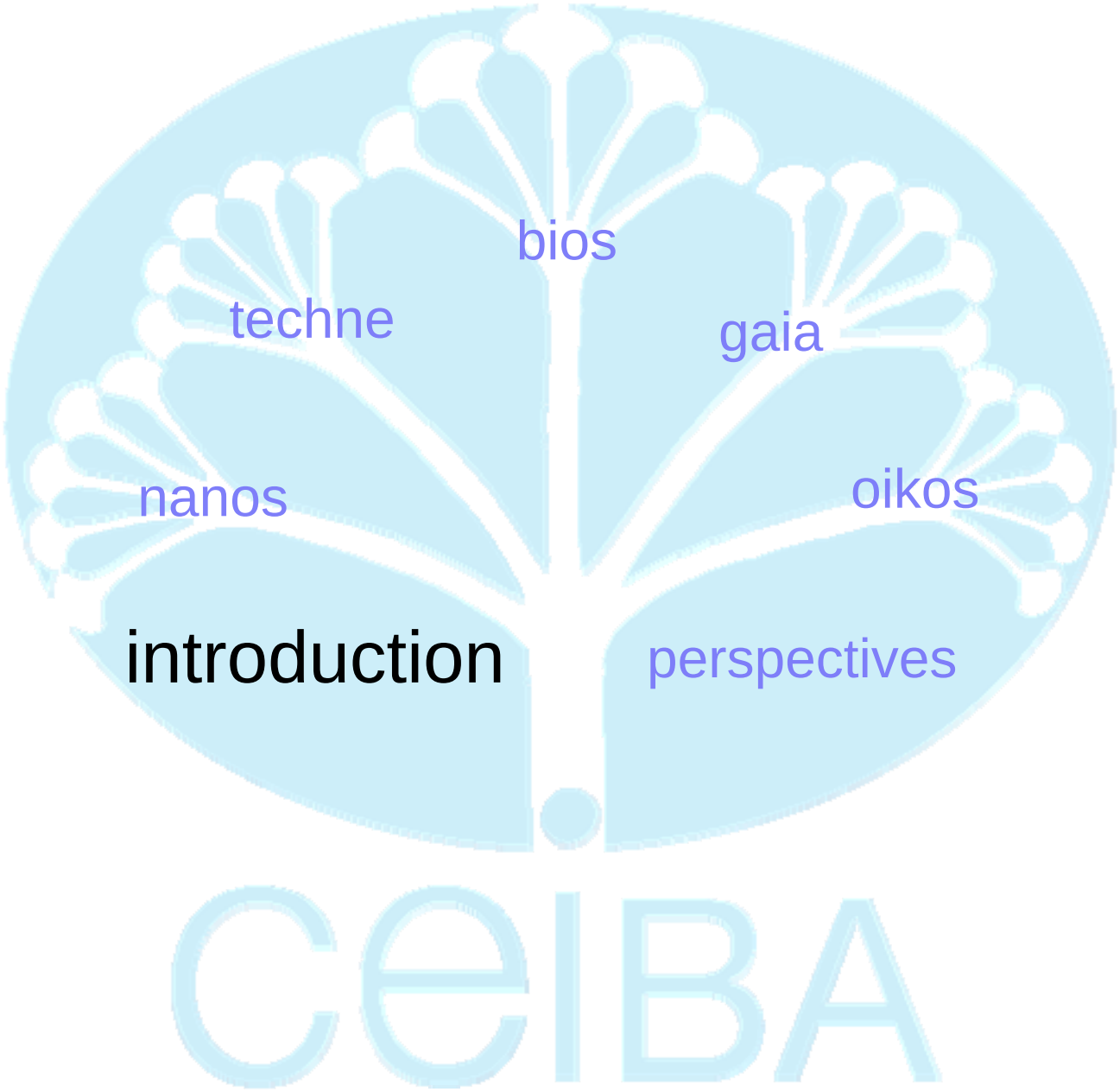
Centro de Estudios Interdisciplinarios Básicos y Aplicados en Complejidad CeiBA-Complejidad

Creating a Center of Excellence in Complex-Systems Research for Colombia





Some history

Since 2004 Colciencias is realizing a program for the creation of centers of excellence in research. This initiative has been made possible by national resources and loans by international institutions. Following a strategic program, the following centers have been implemented till now:

- New materials
- Biotechnology
- Tropical diseases
- Environment
- Culture and institutions

Why create a center on complexity in Colombia?

As complexity science develops, its focus is shifting from fundamental questions towards more specific and more applied problems, and its range extends towards ever larger and ever smaller scales, thus opening new opportunities for research and innovation in the field.

A host of problems specific to tropical developing countries require approaches based on complexity in order to be solved in a sustainable manner.

Studies in complexity are essentially theoretical in character and therefore easier to finance than any experimentally oriented research.

Why create a center on complexity in Colombia?

There is an incipient community in Colombia working on complexity, with fresh enthusiasm but lacking a forum to bundle, coordinate, and concentrate these diverse efforts.

Colombia already has a leading position within the Andean and Caribbean regions in research and higher education and therefore suggests itself as a strategic site for a center with regional impact.

How?

Some existing institutions that serve as **models** for our center:

- Santa Fe Institute (SFI), New Mexico, USA
- Max Planck Institute for the Physics of Complex Systems (MPIPKS), Dresden, Germany
- Brazilian Center for Research in Physics (CBPF), Rio de Janeiro, Brazil

However, our endeavor is **different** in some important aspects.

- Broad interdisciplinary spectrum of research subjects
- Dedication to problems specific for tropical regions / developing countries
- Emphasis on applications and consulting

How?

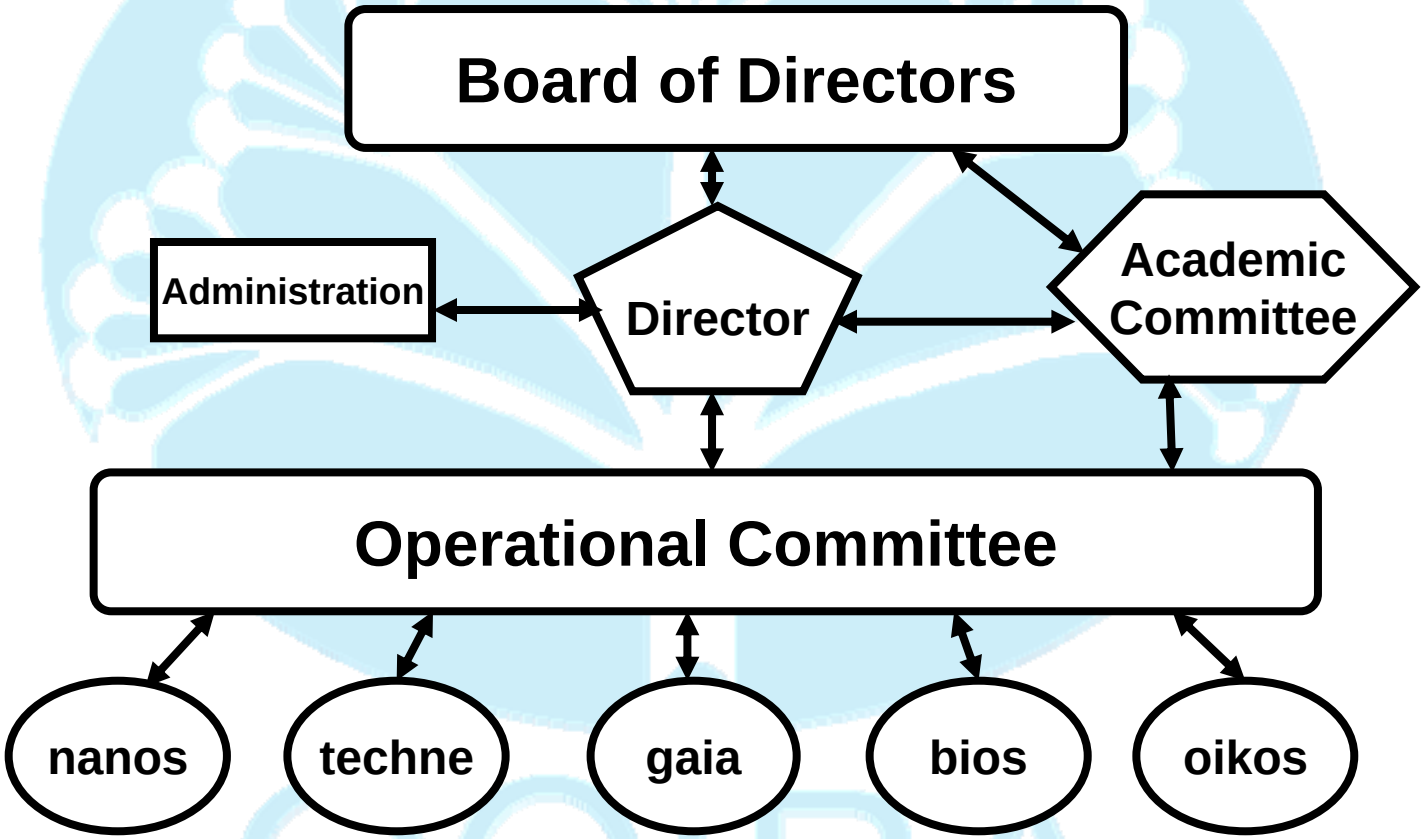
In view of the large number of research groups and their broad thematic spectrum, the center will have a tree structure comprising three levels, the central level, five thematically defined domains -

nanos	natural and artificial nanosystems
techne	technology and industrial processes
bios	biological systems, ecosystems, and biologically-inspired systems
gaia	terrestrial, atmospheric, and oceanic processes in interaction with ecosystems
oikos	socio-economic systems

and the 25 individual research groups.

How?

Administrative structure:



Who?

The center will be operated as a joint venture of the following institutions (all in Bogota):

- 45% Universidad Nacional de Colombia (UNAL), public
- 45% Universidad de los Andes (UniAndes), private
- 5% Pontificia Universidad Javeriana (PUJ), confessional
- 5% Universidad del Rosario (URosario), confessional

Percentages refer to the number of participating groups as well as to the share in the budget.

What?

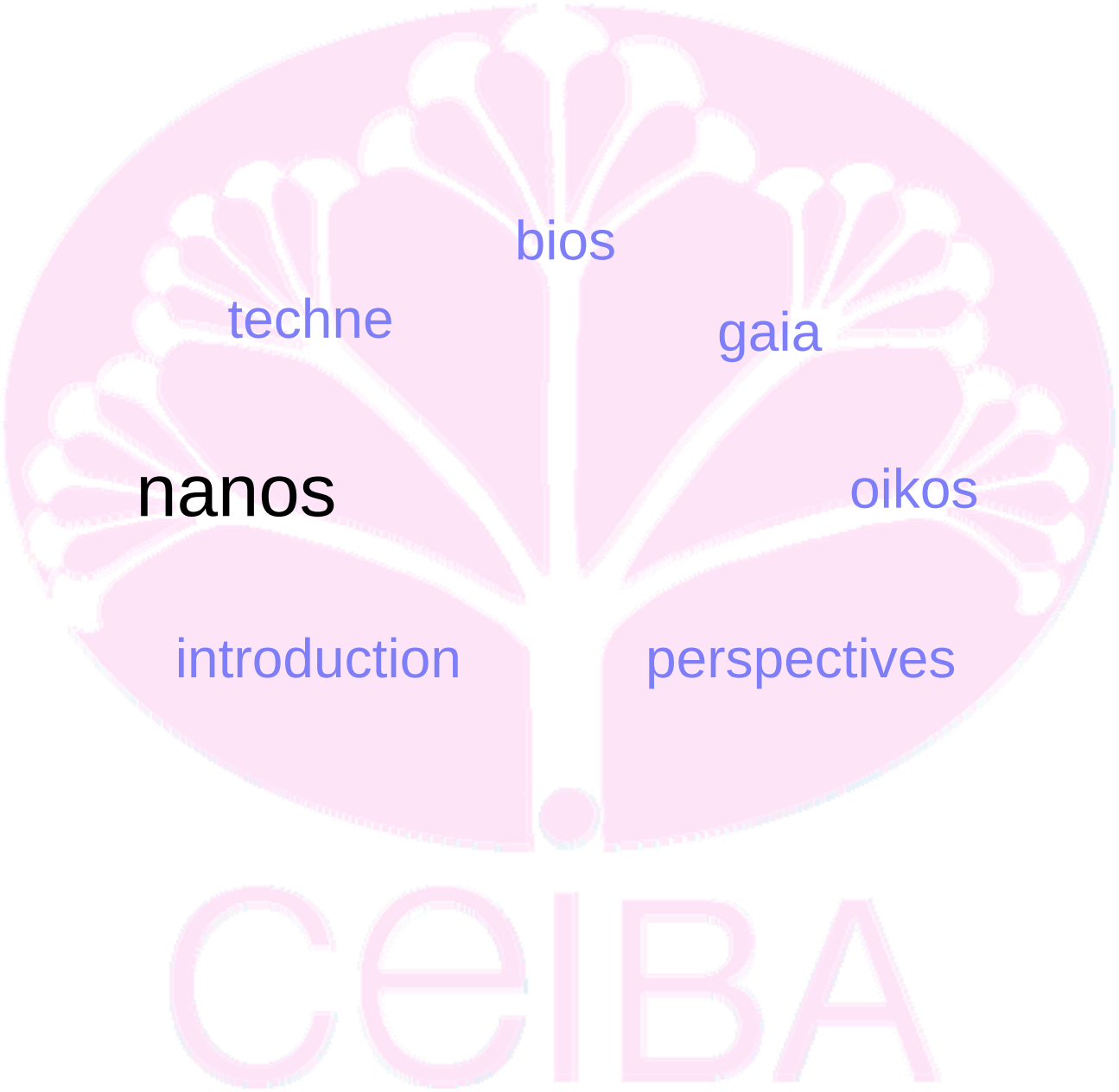
The five-year budget of the center will amount to approximately:

- USD 1.7 millions from Colciencias
- USD 1.7 millions from participating institutions

It will be dedicated principally to:

- 50 % PhD / postdoctoral fellowships
- 15 % events (conferences, summer schools …) and visitors program
- 15 % equipment and infrastructure
- 20 % administration and maintenance

Genus: ceiba



What is “nonlinear nanoscience”?

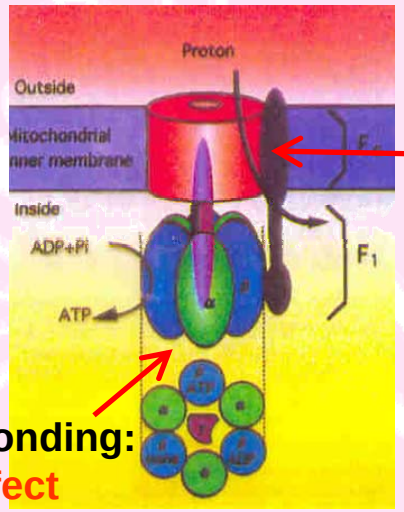
Some constituent features:

- Dynamical complexity
  nonlinear dynamics, multistability, bifurcations, chaos, strange attractors, structural stability
- Quantum effects
  entanglement, nonlocality, tunneling, localization
- Stochasticity
  thermal fluctuations, Brownian motion, random forces
- Many-body effects
  decoherence, dissipation, energy-conversion cascades, collective modes
- Non-equilibrium thermodynamics
  directed transport, structure formation, energy and information flows, dynamical equilibrium, life

nanos

Complex dynamics in nanosystems

Schematic structure

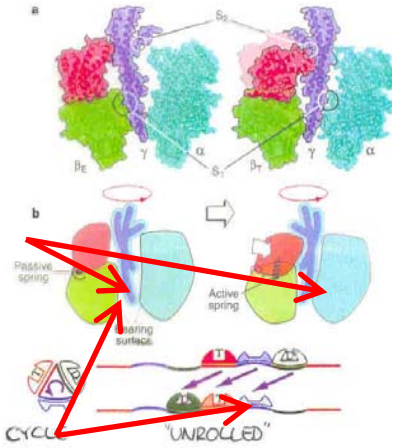


Chemical Bonding:
quantum effect

Mechanical model of F1-ATPase

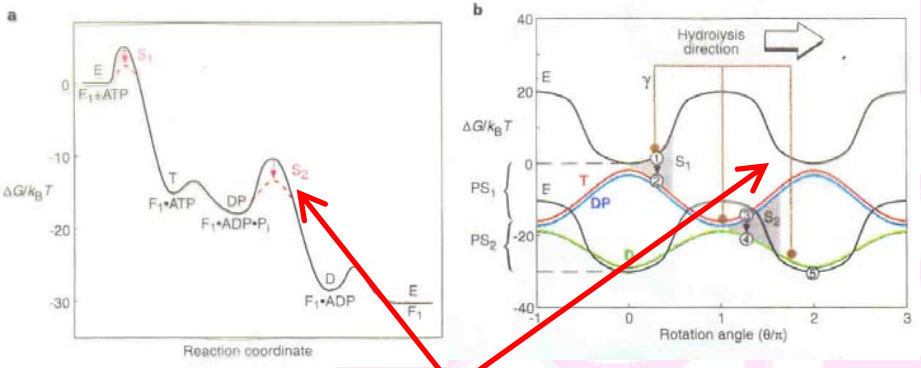
Proton Tunnelling:
quantum effect

Collective Modes:
many-body effect



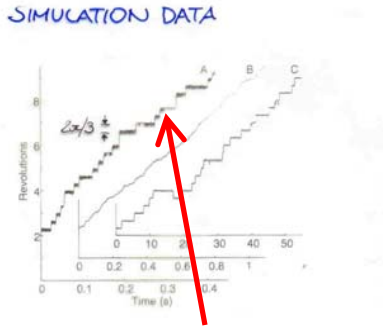
Multistability:
nonlinear dynamics

Mechano-Chemical Cycle



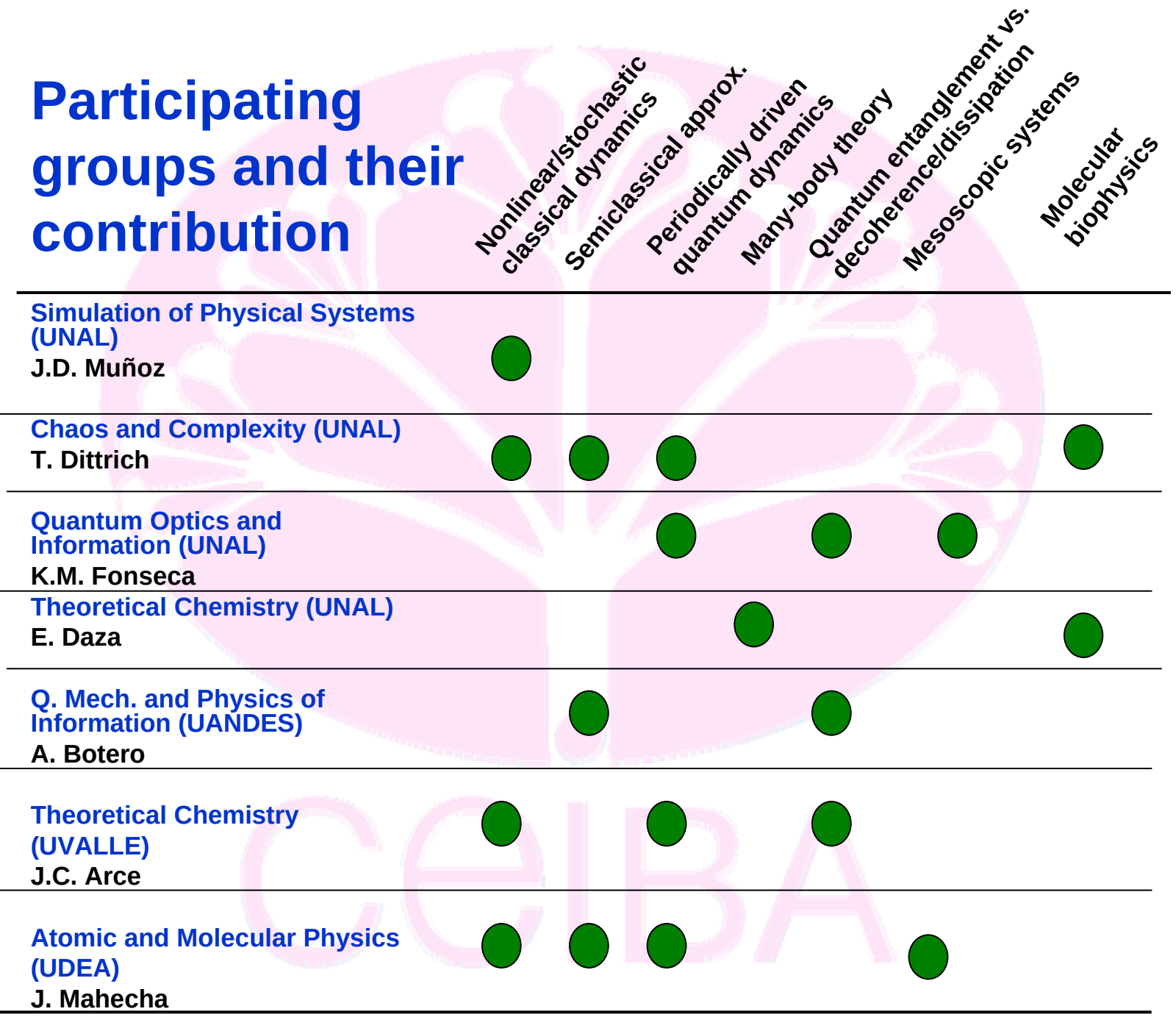
Driving Chemical Reaction-Catalysis:
non-equilibrium thermodynamics

Simulation Data

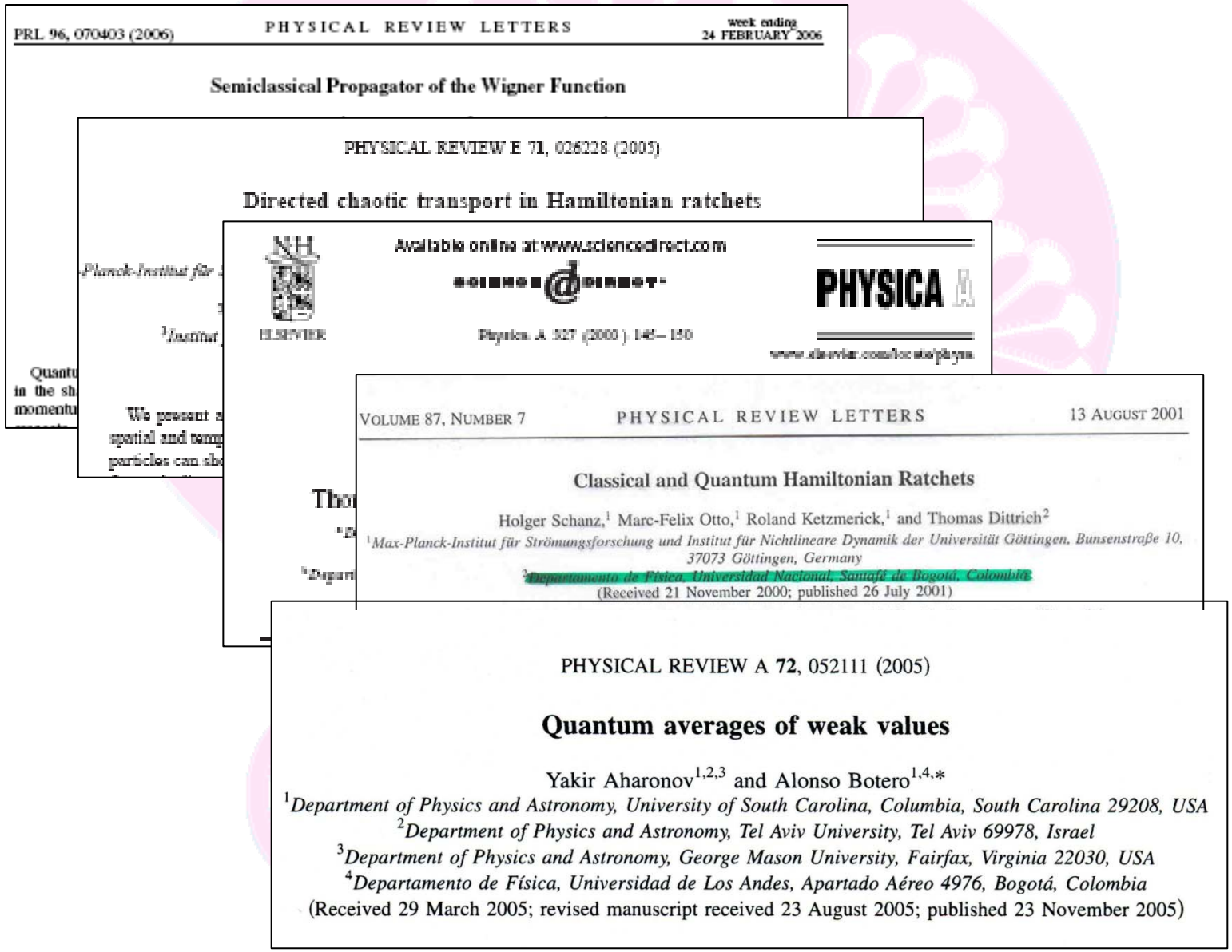


Fluctuating Force:
stochasticity

Participating groups and their contribution



nanos



PRL 96, 070403 (2006) PHYSICAL REVIEW LETTERS week ending 24 FEBRUARY 2006

Semiclassical Propagator of the Wigner Function

PHYSICAL REVIEW E 71, 026228 (2005)

Directed chaotic transport in Hamiltonian ratchets

Available online at www.sciencedirect.com

PHYSICA A

VOLUME 87, NUMBER 7 PHYSICAL REVIEW LETTERS 13 AUGUST 2001

Classical and Quantum Hamiltonian Ratchets

Holger Schanz,[1] Marc-Felix Otto,[1] Roland Ketzmerick,[1] and Thomas Dittrich[2]

[1]Max-Planck-Institut für Strömungsforschung und Institut für Nichtlineare Dynamik der Universität Göttingen, Bunsenstraße 10, 37073 Göttingen, Germany

[2]Departamento de Física, Universidad Nacional, Santafé de Bogotá, Colombia

(Received 21 November 2000; published 26 July 2001)

PHYSICAL REVIEW A **72**, 052111 (2005)

Quantum averages of weak values

Yakir Aharonov[1,2,3] and Alonso Botero[1,4,*]

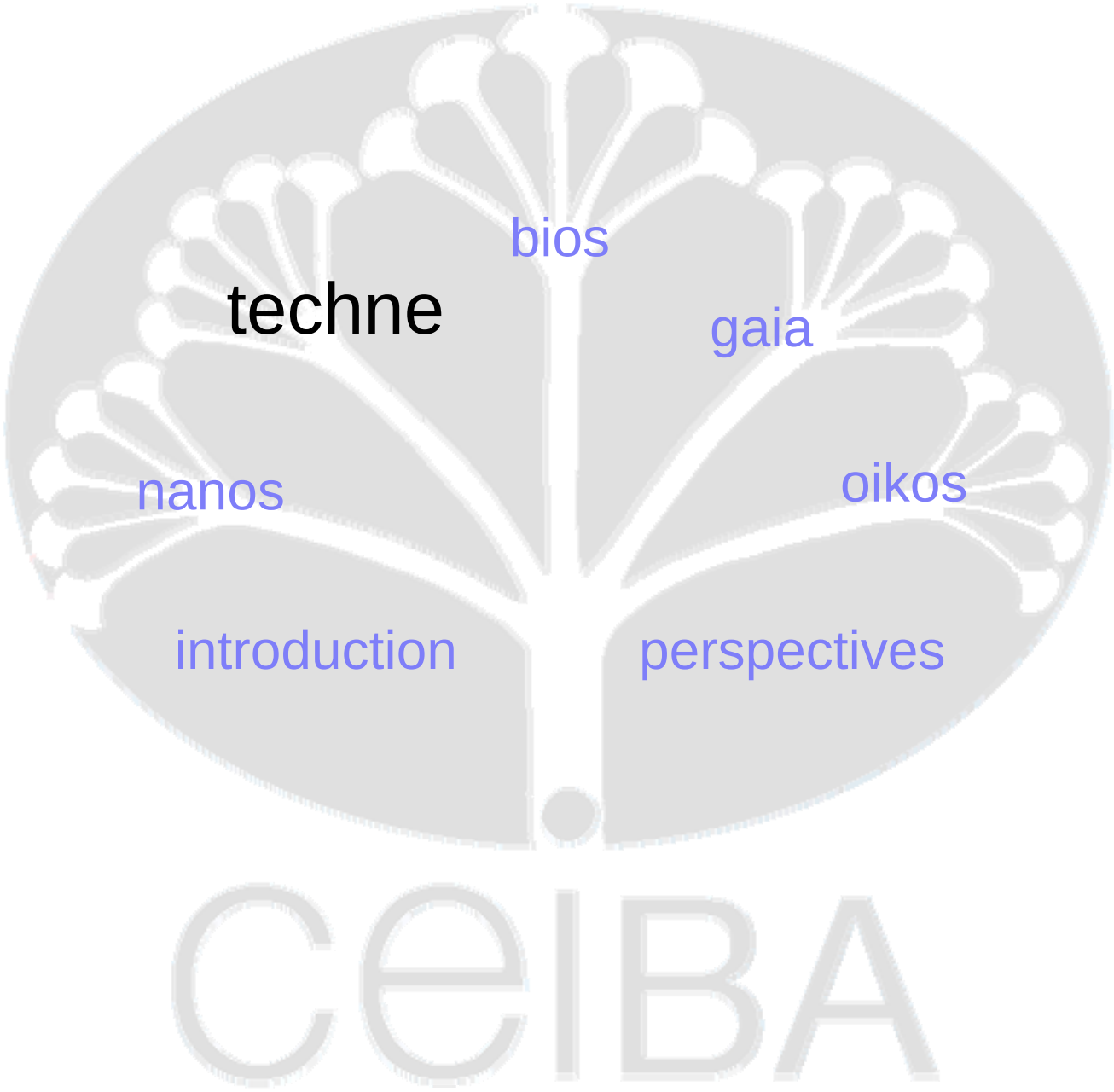
[1]*Department of Physics and Astronomy, University of South Carolina, Columbia, South Carolina 29208, USA*

[2]*Department of Physics and Astronomy, Tel Aviv University, Tel Aviv 69978, Israel*

[3]*Department of Physics and Astronomy, George Mason University, Fairfax, Virginia 22030, USA*

[4]*Departamento de Física, Universidad de Los Andes, Apartado Aéreo 4976, Bogotá, Colombia*

(Received 29 March 2005; revised manuscript received 23 August 2005; published 23 November 2005)



techne

Materials and processes of industrial and technical interest:

- Granular media
- Chemical processes
- Electronic systems and natural computation
- Operations research and operations management

Why are they complex?

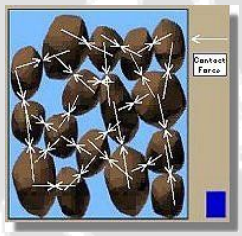
Some constituent features:

- **Multiscale hierarchies**
  Micro-macro descriptions, structure formation, fractal structures, collective behaviours
- **Nonlinear interactions**
  Nonlinear dynamics, bifurcations, chaos
- **Nontrivial statistics**
  Phase transitions and power laws, stochasticity
- **Nonequilibrium thermodynamics**
  SOC, irreversible processes, dissipation, energy flows, dynamical equilibrium
- **Hierarchical and combinatorial structure**
  NP Problems, nonlinear dynamics, network modelling

techne

Soils

Micromechanics

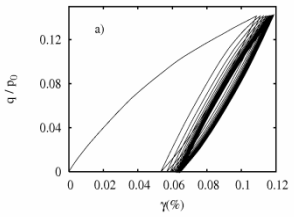


Non-linear dynamics

Multiscale hierarchies

Constitutive Equations

$$\overset{\nabla}{\boldsymbol{\sigma}} = \boldsymbol{L}(\boldsymbol{\sigma}, q)\,\boldsymbol{d} + \frac{1}{\|\boldsymbol{d}\|}\boldsymbol{Q}(\boldsymbol{\sigma}, q)\,[\boldsymbol{d} \otimes \boldsymbol{d}]$$

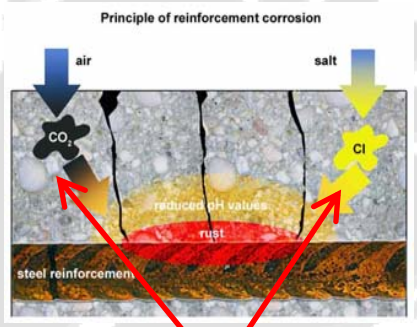


Ratcheting

Avalanches (GAIA)

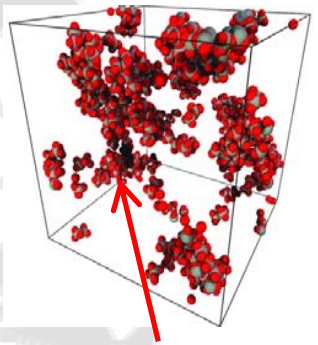
Concrete

Corrosion



Anomalous Diffusion

Gelation



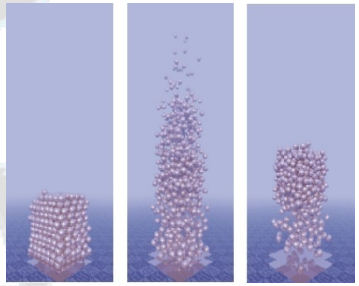
Structures and Fractals

Dissipation

Grains

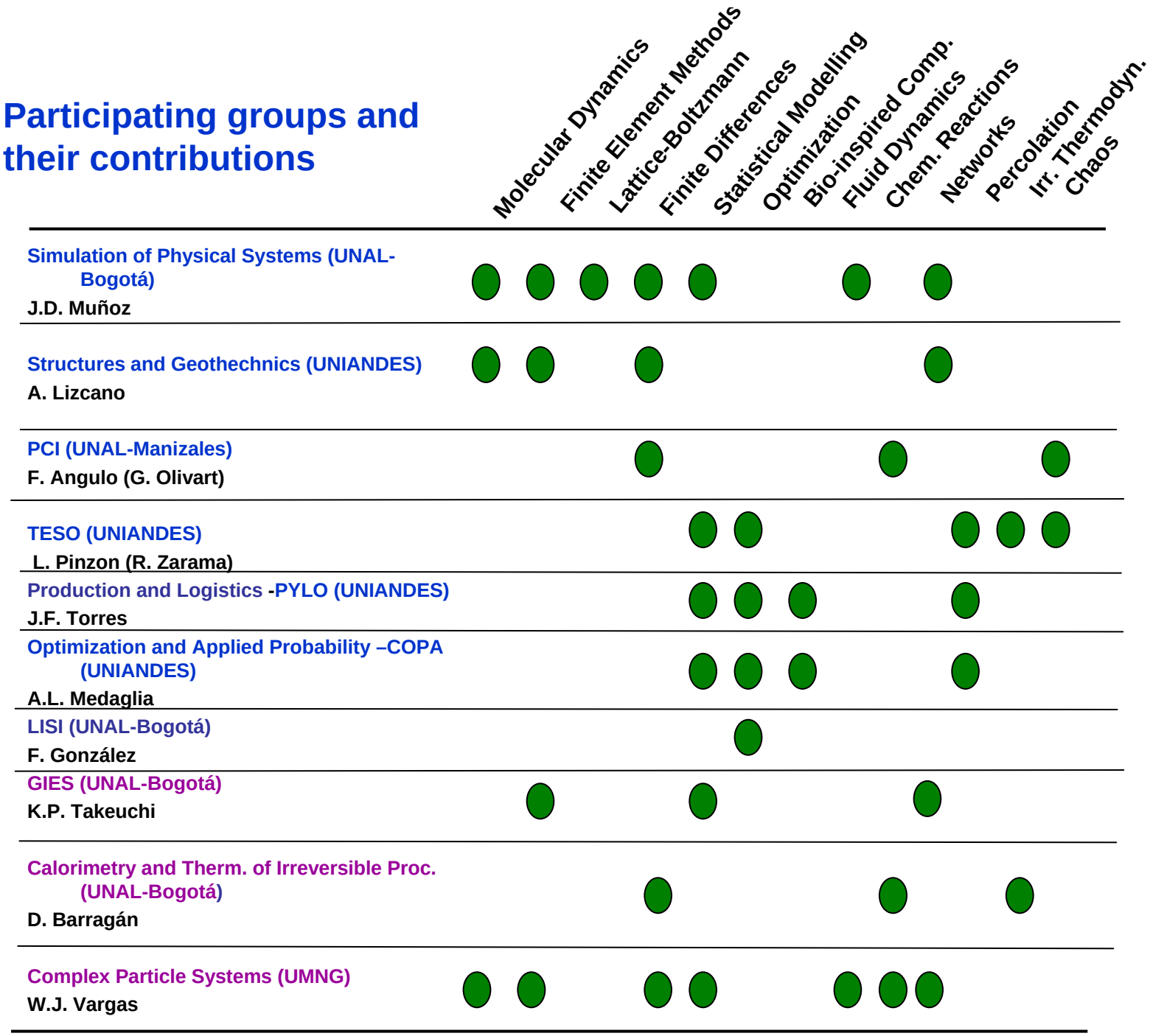
SOC

Collective Behavior

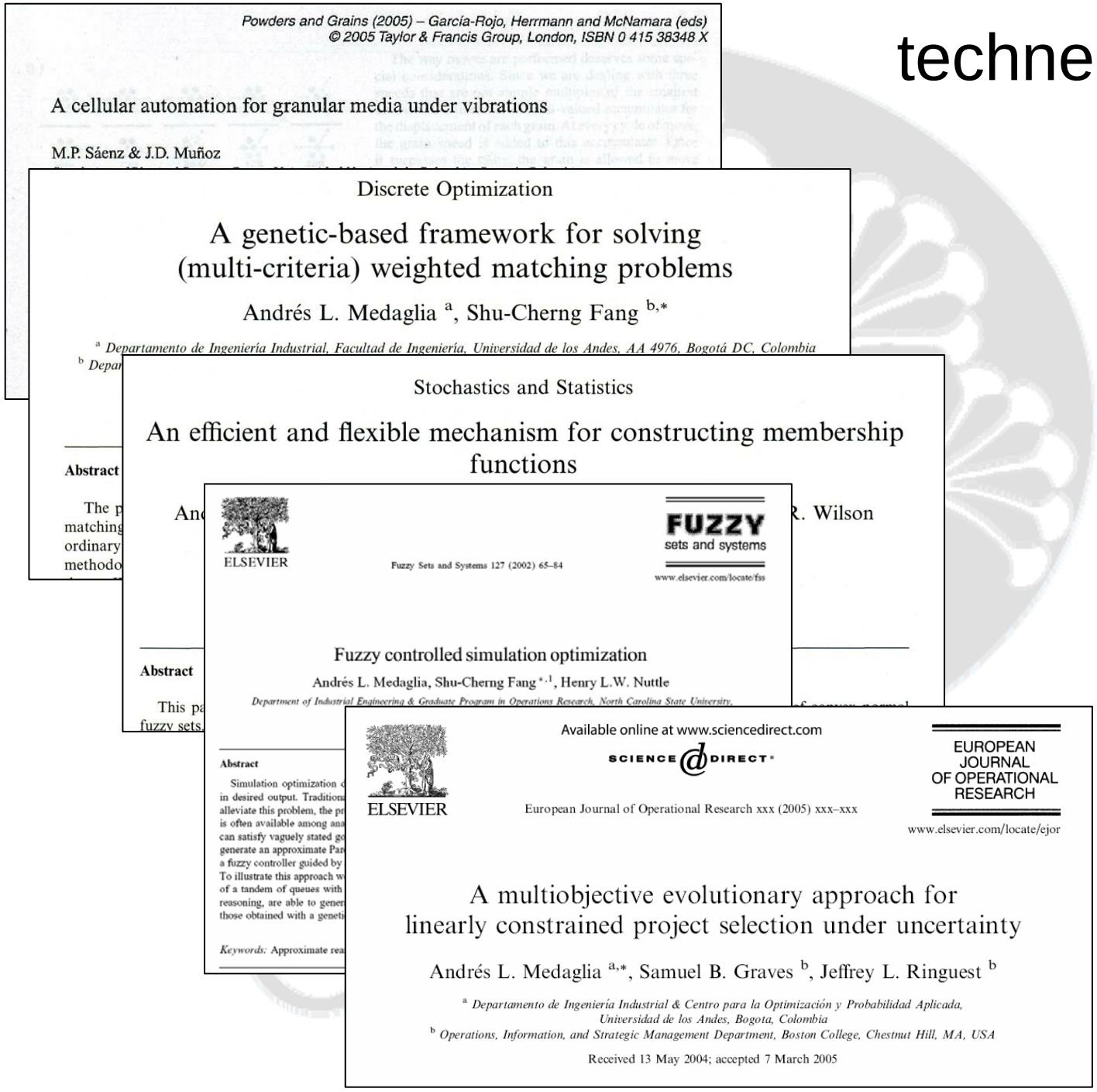


Leidenfrost

Participating groups and their contributions



techne



Powders and Grains (2005) – García-Rojo, Herrmann and McNamara (eds)
© 2005 Taylor & Francis Group, London, ISBN 0 415 38348 X

A cellular automation for granular media under vibrations

M.P. Sáenz & J.D. Muñoz

Discrete Optimization

A genetic-based framework for solving (multi-criteria) weighted matching problems

Andrés L. Medaglia [a], Shu-Cherng Fang [b,*]

[a] Departamento de Ingeniería Industrial, Facultad de Ingeniería, Universidad de los Andes, AA 4976, Bogotá DC, Colombia

Stochastics and Statistics

An efficient and flexible mechanism for constructing membership functions

ELSEVIER

Fuzzy Sets and Systems 127 (2002) 65–84

FUZZY sets and systems

www.elsevier.com/locate/fss

Fuzzy controlled simulation optimization

Andrés L. Medaglia, Shu-Cherng Fang *,1, Henry L.W. Nuttle

Department of Industrial Engineering & Graduate Program in Operations Research, North Carolina State University,

Available online at www.sciencedirect.com

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European Journal of Operational Research xxx (2005) xxx–xxx

EUROPEAN JOURNAL OF OPERATIONAL RESEARCH

www.elsevier.com/locate/ejor

A multiobjective evolutionary approach for linearly constrained project selection under uncertainty

Andrés L. Medaglia [a,*], Samuel B. Graves [b], Jeffrey L. Ringuest [b]

[a] Departamento de Ingeniería Industrial & Centro para la Optimización y Probabilidad Aplicada, Universidad de los Andes, Bogota, Colombia

[b] Operations, Information, and Strategic Management Department, Boston College, Chestnut Hill, MA, USA

Received 13 May 2004; accepted 7 March 2005

bios

techne

gaia

nanos

oikos

introduction

perspectives

bios

The human body as a complex system

The human body is a structural and dynamical hierarchy of quasi-autonomous agents and systems:

Structural hierarchy:
- Physical objects (quantum & classical)
- Cells
- Tissues
- Organs
- Physiological systems

Dynamical hierarchy:
- Genome
- Proteome
- Metabolome
- Physiome

Participating groups

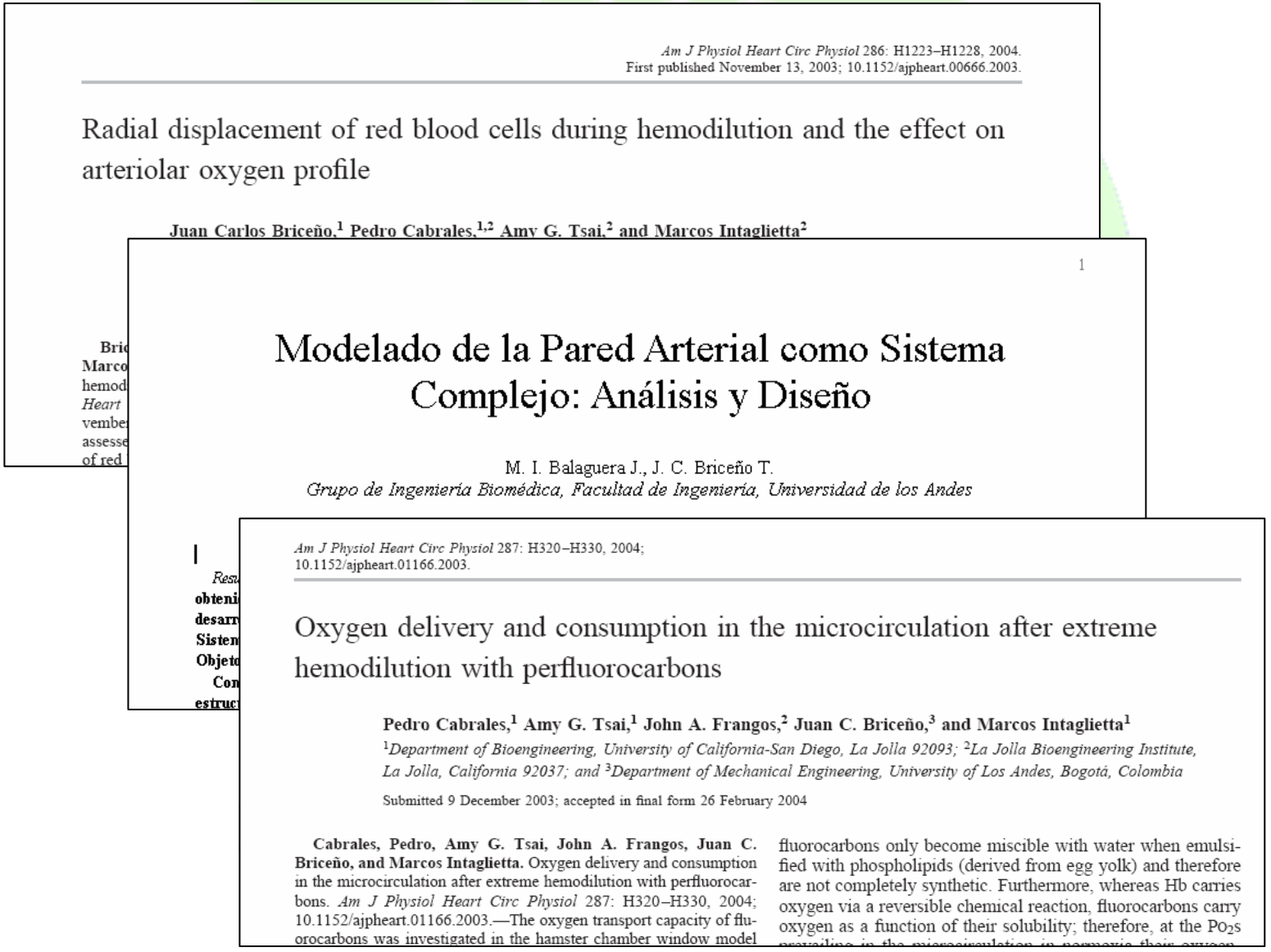
Member groups:

- Biomedical Engineering Group, Universidad de Los Andes
- Animal-plant interactions, Universidad Nacional

Adjoint groups:

- Fundación Cardio Infantil
- Dental Research Center, Universidad Javeriana

bios



Am J Physiol Heart Circ Physiol 286: H1223–H1228, 2004.
First published November 13, 2003; 10.1152/ajpheart.00666.2003.

Radial displacement of red blood cells during hemodilution and the effect on arteriolar oxygen profile

Juan Carlos Briceño,[1] Pedro Cabrales,[1,2] Amy G. Tsai,[2] and Marcos Intaglietta[2]

1

Modelado de la Pared Arterial como Sistema Complejo: Análisis y Diseño

M. I. Balaguera J., J. C. Briceño T.
Grupo de Ingeniería Biomédica, Facultad de Ingeniería, Universidad de los Andes

Am J Physiol Heart Circ Physiol 287: H320–H330, 2004;
10.1152/ajpheart.01166.2003.

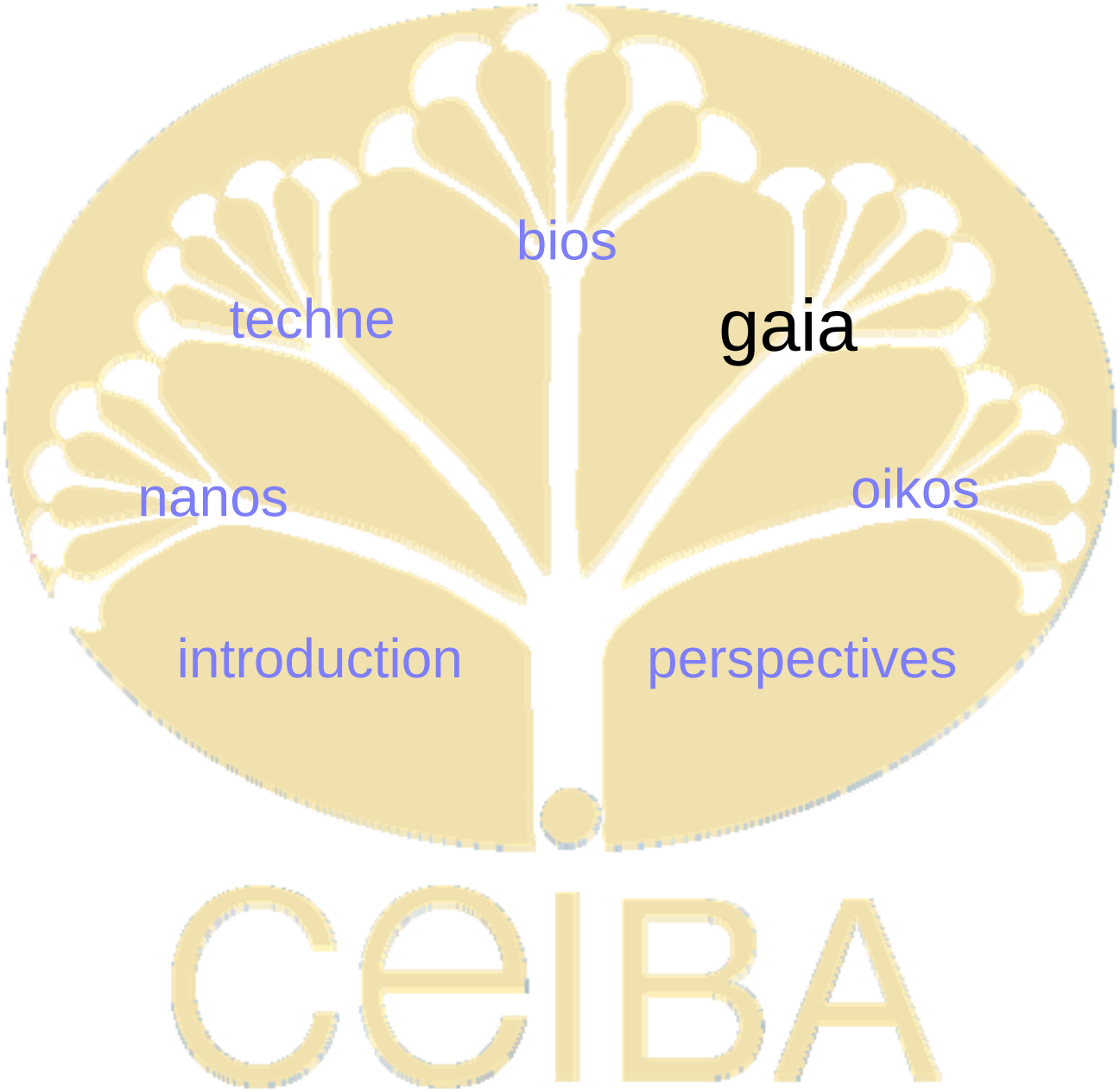
Oxygen delivery and consumption in the microcirculation after extreme hemodilution with perfluorocarbons

Pedro Cabrales,[1] Amy G. Tsai,[1] John A. Frangos,[2] Juan C. Briceño,[3] and Marcos Intaglietta[1]
[1]*Department of Bioengineering, University of California-San Diego, La Jolla 92093;* [2]*La Jolla Bioengineering Institute, La Jolla, California 92037; and* [3]*Department of Mechanical Engineering, University of Los Andes, Bogotá, Colombia*

Submitted 9 December 2003; accepted in final form 26 February 2004

Cabrales, Pedro, Amy G. Tsai, John A. Frangos, Juan C. Briceño, and Marcos Intaglietta. Oxygen delivery and consumption in the microcirculation after extreme hemodilution with perfluorocarbons. *Am J Physiol Heart Circ Physiol* 287: H320–H330, 2004; 10.1152/ajpheart.01166.2003.—The oxygen transport capacity of fluorocarbons was investigated in the hamster chamber window model

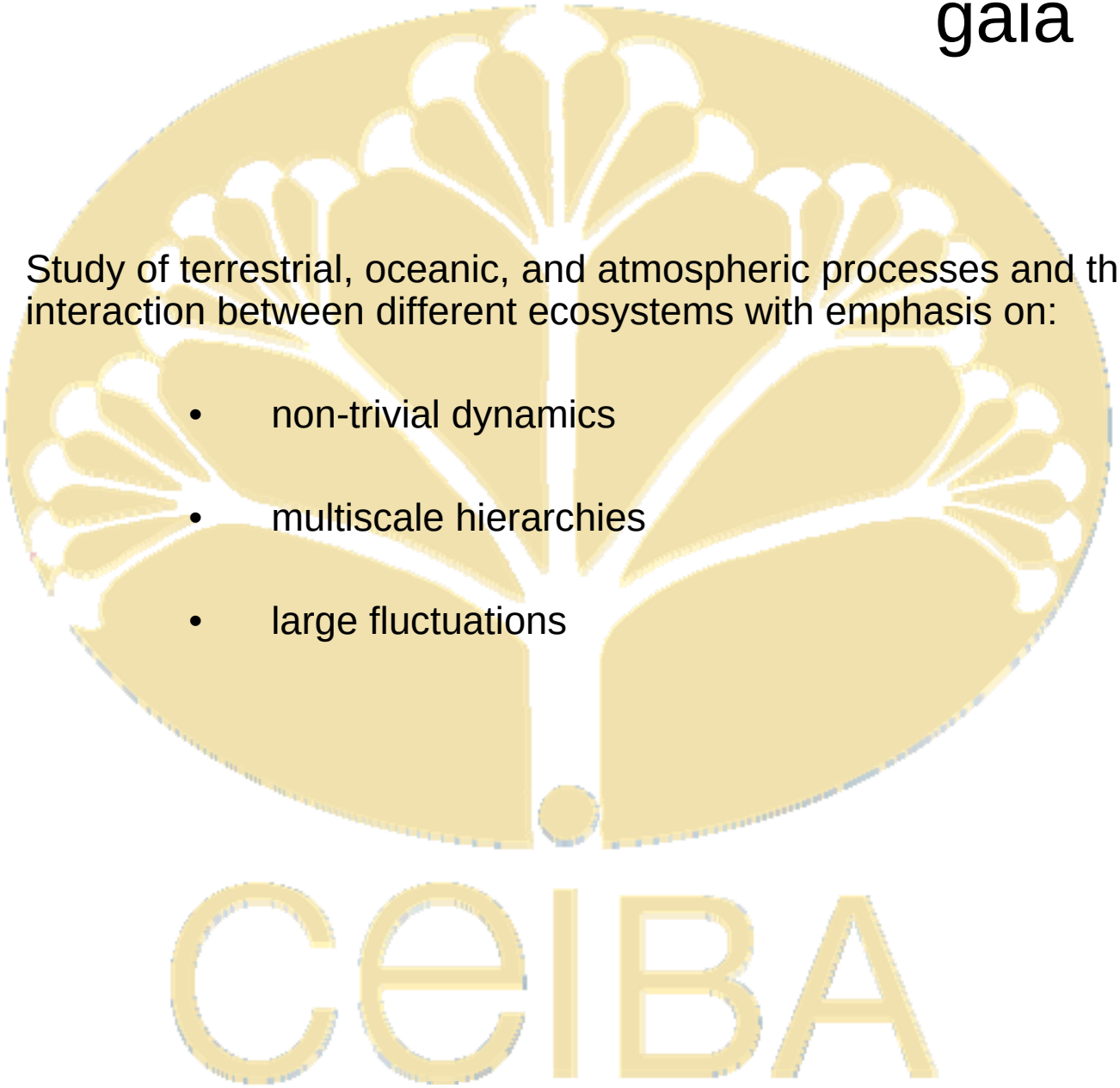
fluorocarbons only become miscible with water when emulsified with phospholipids (derived from egg yolk) and therefore are not completely synthetic. Furthermore, whereas Hb carries oxygen via a reversible chemical reaction, fluorocarbons carry oxygen as a function of their solubility; therefore, at the P_{O_2}s



gaia

Study of terrestrial, oceanic, and atmospheric processes and the interaction between different ecosystems with emphasis on:

- non-trivial dynamics
- multiscale hierarchies
- large fluctuations



Modeling capabilities

The group of researchers involved in GAIA includes modeling experts working in fundamental and applied disciplines as diverse as air quality, vehicle emissions, atmospheric processes, hydrology, hydraulics, hydrogeology, fluid mechanics, hydrodynamics, water quality, Geophysics and geology.

Previous relevant experience

- Bogotá's air quality model (Uniandes).
- Fractal and multi-fractal characterization of Colombian river basins (PUJ).
- Atmospheric mesoscale modeling and projection of climate change scenarios (UNAL).

gaia

CHAOS AND STOCHASTICITY IN DETERMINISTICALLY GENERATED MULTIFRACTAL MEASURES

CARLOS E. PUENTE
Department of Land, Air and Water Resources, University of California, Davis, USA

NELSON OBREGÓN
Department of Civil Engineering, Universidad Javeriana, Bogotá, Colombia

A GEOMETRIC PLATONIC APPROACH TO MULTIFRACTALITY AND TURBULENCE

CARLOS E. PUENTE*
Hydrologic Science, Land, Air and Water Resources, and Institute of Theoretical Dynamics, University of California, Davis, California 95616

NELSON OBREGON†
Civil Engineering Department, Pontificia Universidad Javeriana,

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Atmospheric Environment 38 (2004) 4291–4303

ATMOSPHERIC ENVIRONMENT

www.elsevier.com/locate/atmosenv

Measurements of nitrous oxide emissions from light-duty motor vehicles: a pilot study

Eduardo Behrentz[a], Richa

[a] *Environmental Science and Engineering Progra*
University o
[b] *Monitoring and Laboratory Division, Califo*

Received

Abstract

Dynamometer testing in conjunction with h
of nitrous oxide (N_2O) from a fleet of 37 light
were collected for two driving cycles: the Urb

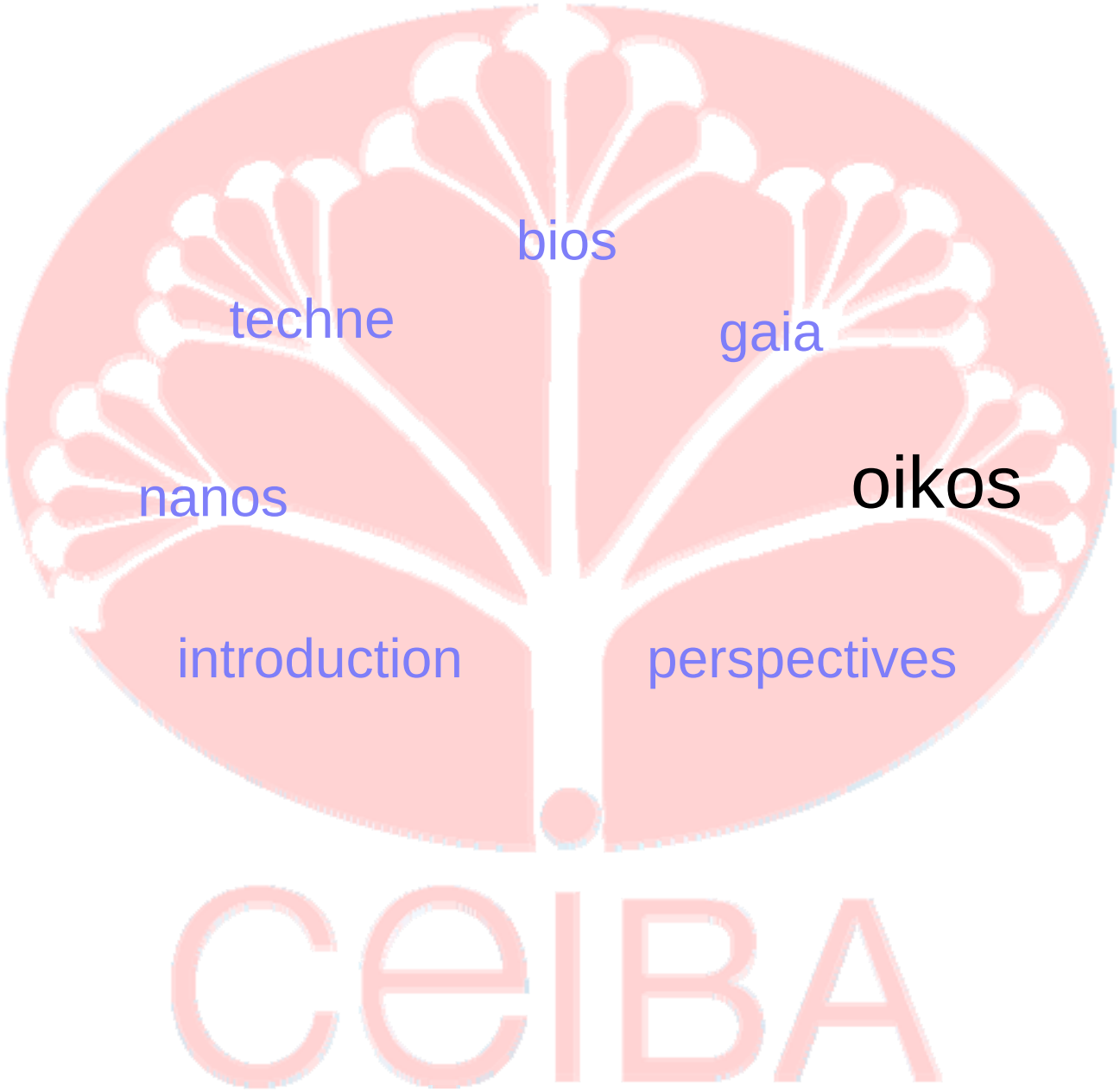
PROJECTIONS OFF FRACTAL FUNCTIONS: A NEW VISION OF NATURE'S COMPLEXITY

CARLOS E. PUENTE*†‡, NELSON OBREGON§, OSCAR ROBAYO†, MARTA G. PUENTE† and DEMIRAY SIMSEK†

†*Hydrologic Science, Land, Air and Water Resources, University of California, Davis, CA 95616*

‡*Institute of Theoretical Dynamics, University of California, Davis, CA 95616*

§*Civil Engineering Department, Pontificia Universidad Javeriana, Bogotá, Colombia*



oikos

Complexity in social sciences and macroeconomy

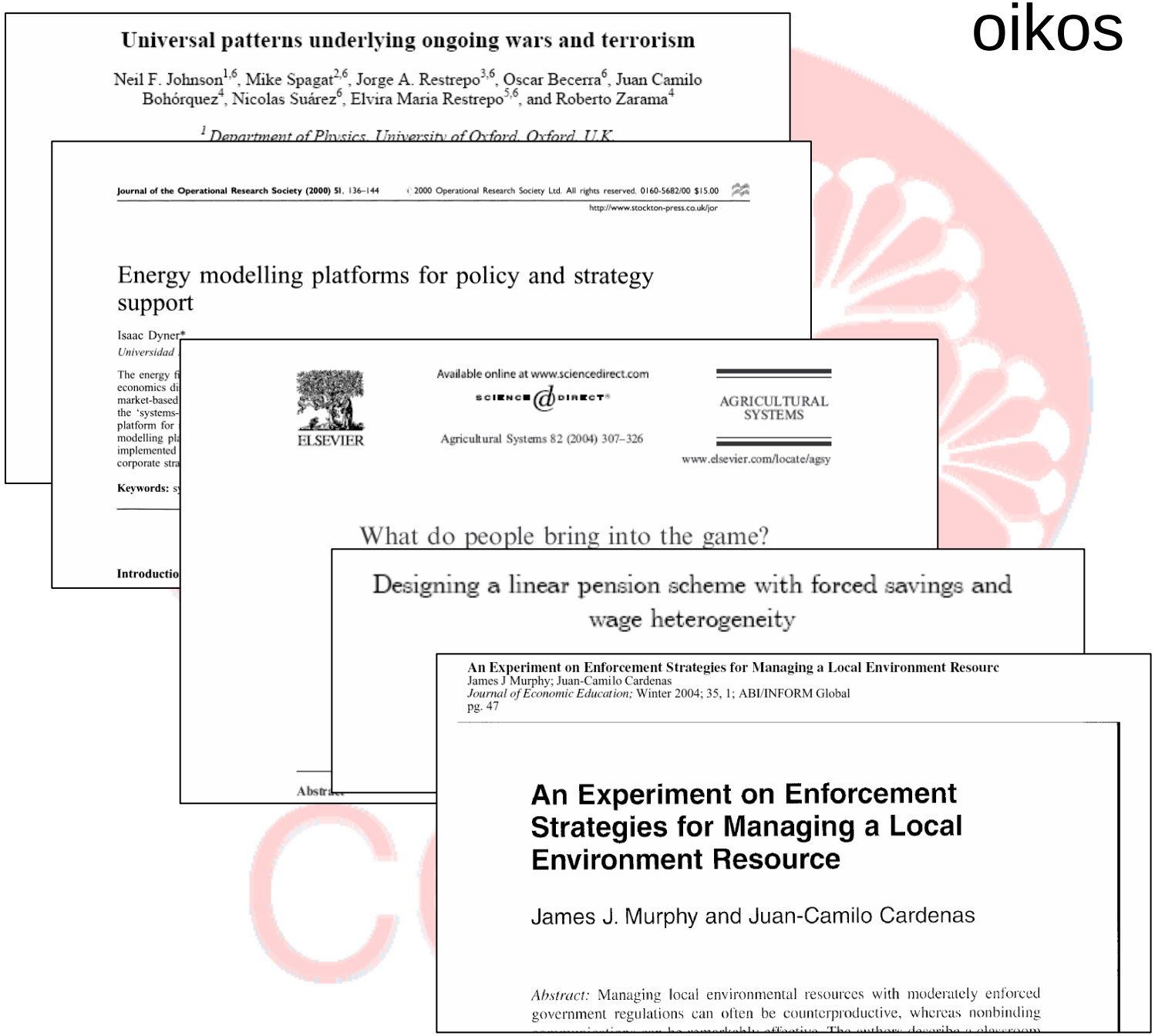
- nonlinearities, feed-backs and nontrivial delays, far from stationary or equilibrium conditions
- non-homogeneous connectivity networks and modular structural arrangements
- non-trivial statistical properties
- emergent organizations
- multiscale hierarchies
- system robustness

oikos

Research topics

- Socio-economic development
- Crime and justice
- Public-policy design
- Public goods and collective action
- Social networks
- Interrelations between these five topics

oikos



Universal patterns underlying ongoing wars and terrorism

Neil F. Johnson[1,6], Mike Spagat[2,6], Jorge A. Restrepo[3,6], Oscar Becerra[6], Juan Camilo Bohórquez[4], Nicolas Suárez[6], Elvira Maria Restrepo[5,6], and Roberto Zarama[4]

[1] *Department of Physics, University of Oxford, Oxford, U.K.*

Journal of the Operational Research Society (2000) 51, 136–144 © 2000 Operational Research Society Ltd. All rights reserved. 0160-5682/00 $15.00

http://www.stockton-press.co.uk/jor

Energy modelling platforms for policy and strategy support

Isaac Dyner*

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Available online at www.sciencedirect.com

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Agricultural Systems 82 (2004) 307–326

AGRICULTURAL SYSTEMS

www.elsevier.com/locate/agsy

What do people bring into the game?

Designing a linear pension scheme with forced savings and wage heterogeneity

An Experiment on Enforcement Strategies for Managing a Local Environment Resource

James J Murphy; Juan-Camilo Cardenas

Journal of Economic Education; Winter 2004; 35, 1; ABI/INFORM Global

pg. 47

An Experiment on Enforcement Strategies for Managing a Local Environment Resource

James J. Murphy and Juan-Camilo Cardenas

Abstract: Managing local environmental resources with moderately enforced government regulations can often be counterproductive, whereas nonbinding

Hopes

- Achieve regional leadership in complexity science
- Attract visitors and students from all over the world, in particular from developing countries
- Provide a model for academic quality within Colombia
- Integrate Colombia in the international complex-systems community

Threats

- Disintegration of the five domains
- Infection by mediocrity
- Loss of creative vigor, dominance of routine