30 YEARS ON THE BIOMATERIALS ROAD

Open University of Catalonia; Institute for Bioengineering of Catalonia; Technical University of Catalonia; Ciber-bbn; Barcelona; Spain.
Setembre de 2013

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Universitat Oberta de Catalunya

The UOC

- An internationally recognised online university
- Student-centred learning
- The benefits of personalised courses. Flexibility, accessibility and collaboration
- An innovator in ICT-based learning
- A point of reference for the quality of its research and academic work

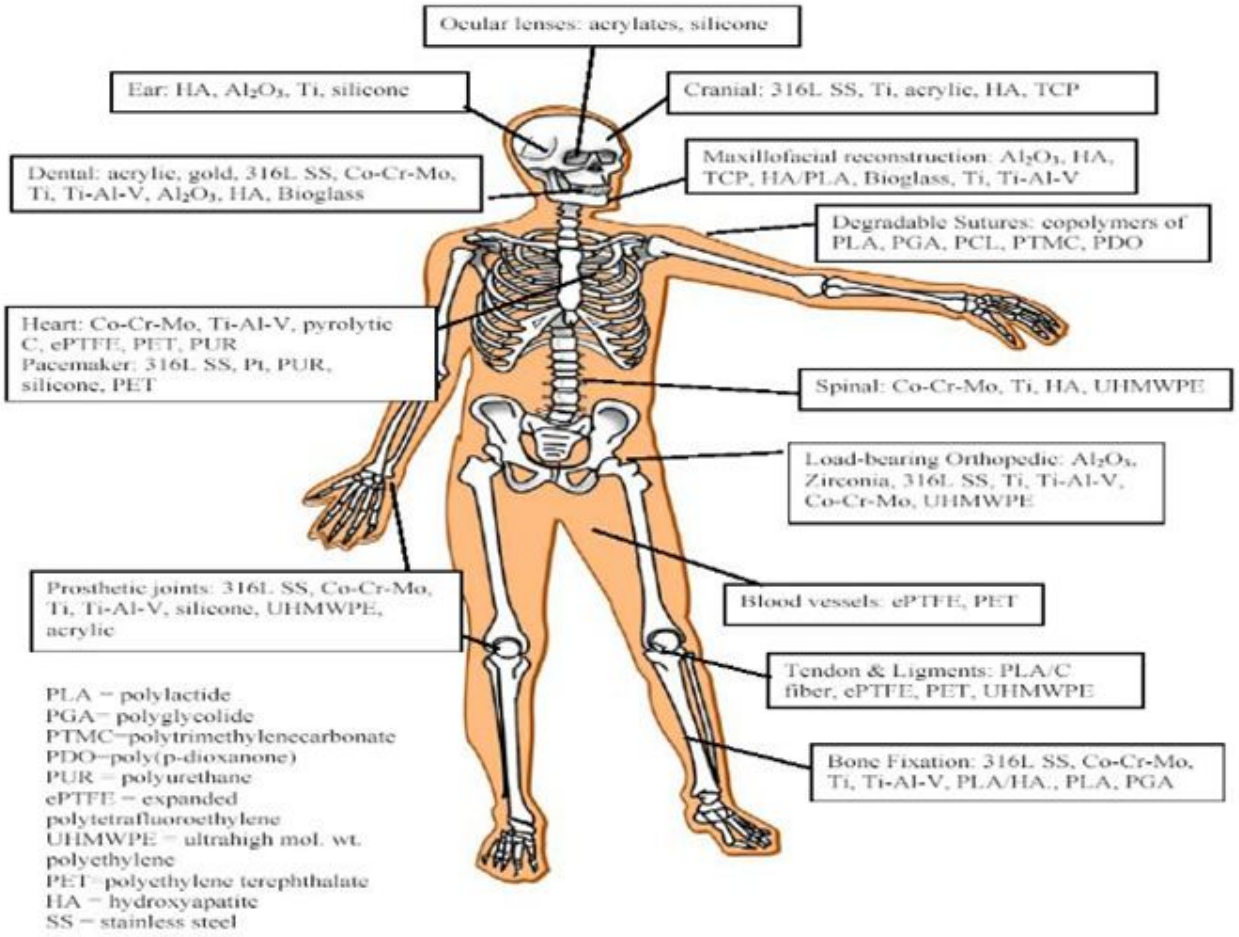
The UOC in figures

- 60,096 students
- 41,784 graduates
- 8,372 virtual classrooms
- 3,720 teaching staff

UOC was created as an on-line University in 1995

Asimov in internet 1986 (You Tube)

about 30 years ago…

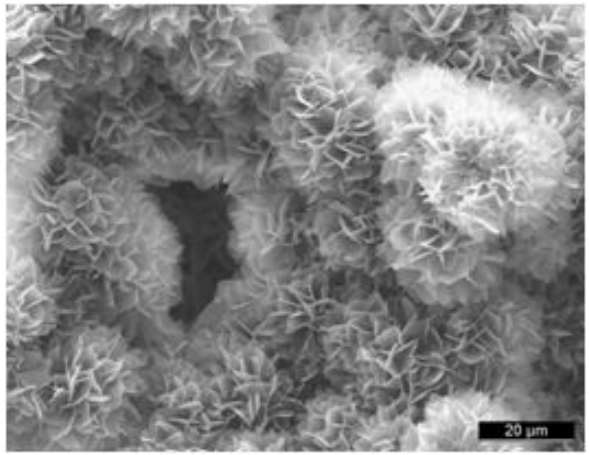


Biomaterials were mainly
oriented to permanent implants, and consisted in inert biomaterials that at present are considered as first generation biomaterials

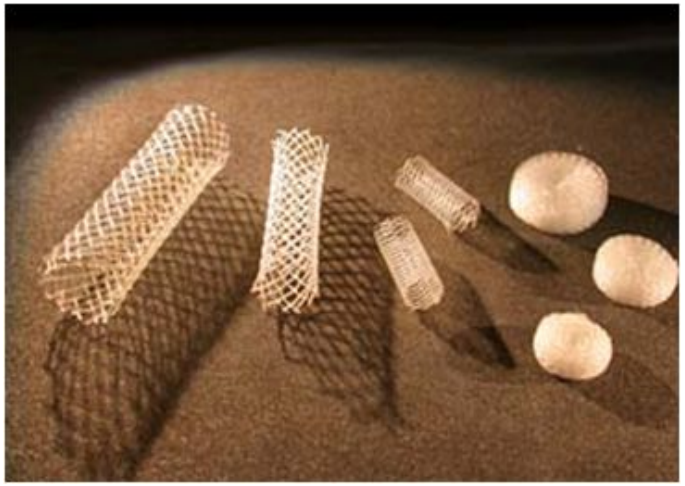
All about Vision. www.allaboutvision.com.
Softec HD (Lenstec Inc.)

Consumer's checkbook. www.checkbook.org

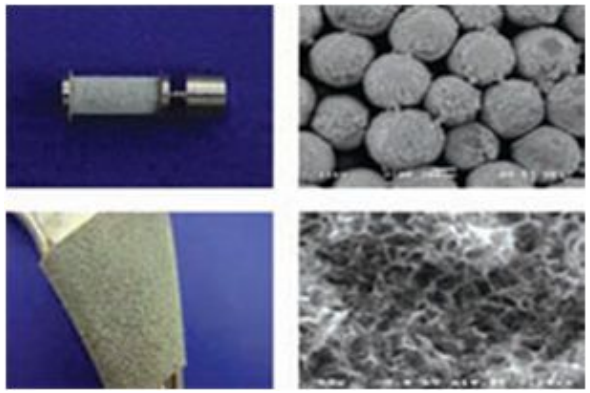
JenFab. www.jenfab.com



Bohner, M., Mater. Today 2010, 13; 24-30

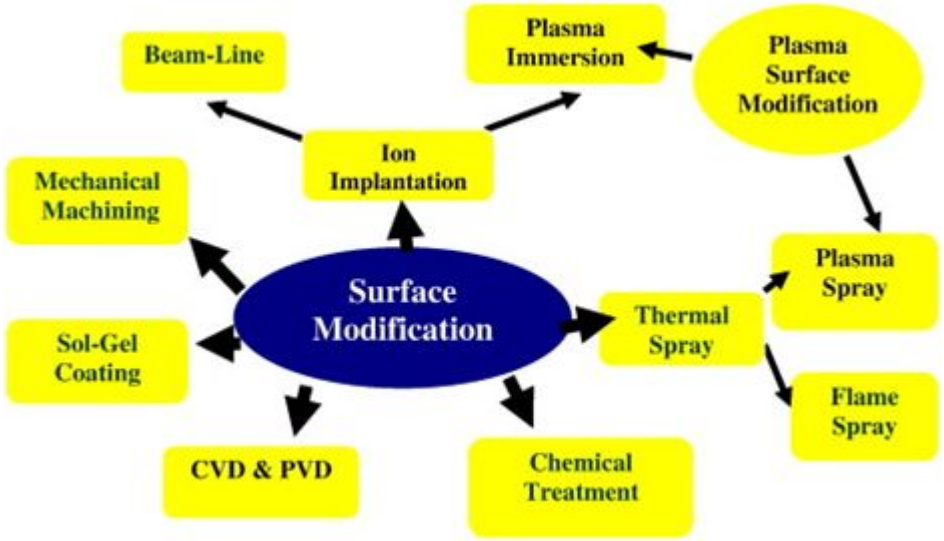


HighTech Filand.
Tampere University of Technology.
www.tut.fi

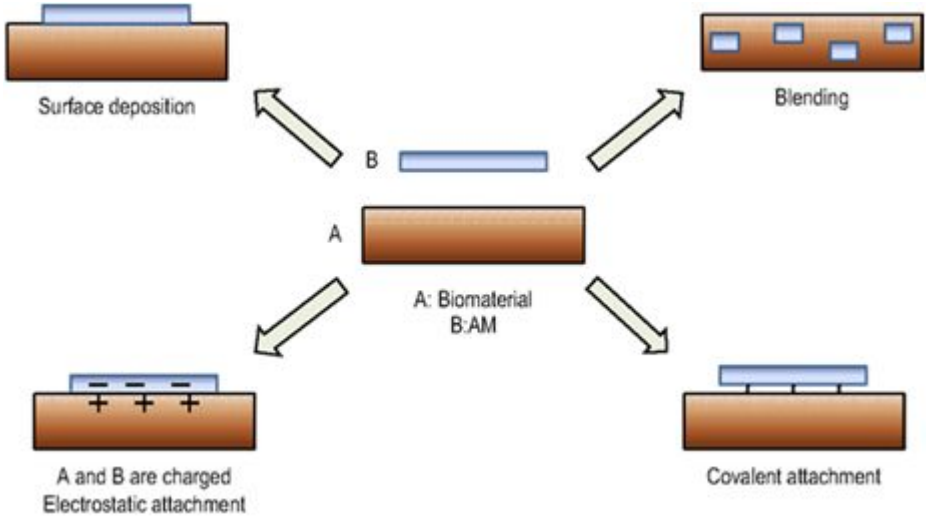


National research council of Canada.
www.nrc-cnrc.gc.ca

In the late 80's and early 90's hydroxyapatite and in general calcium phosphates (including glasses) in bulk, granules or coatings, as well as biodegradable polymers, were central in biomaterials research. Bioactive and biodegradable biomaterials constitute the second generation according to L. Hench.



Chu, P.K., Surf. and Coat. Tech., 2007



Rao, S.S. and Winter J.O., Front. Neuroeng., 2009

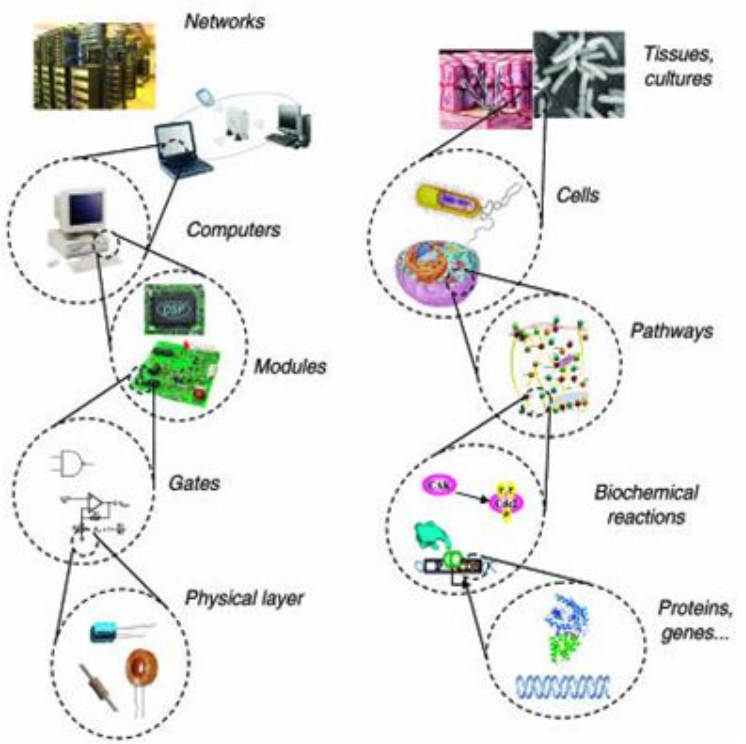
The focus on surfaces becomes progressively more relevant and this leads the way towards what is commonly understood as third generation biomaterials.

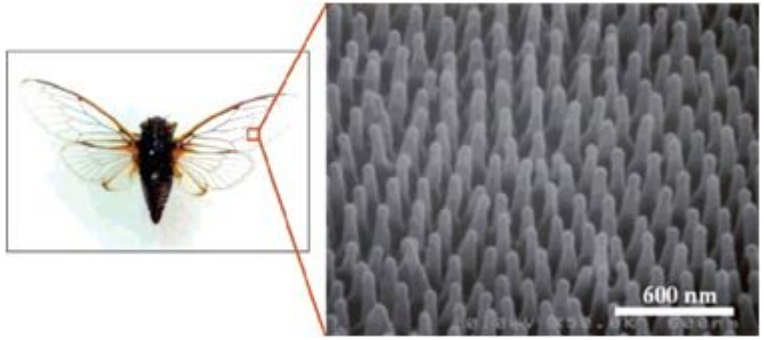
Biomaterial Science and Technology is a real interdisciplinary field

The inputs of computer modelling, macromolecular chemistry, free form fabrication methods and molecular and cellular biology produce an impressive boost to the field.

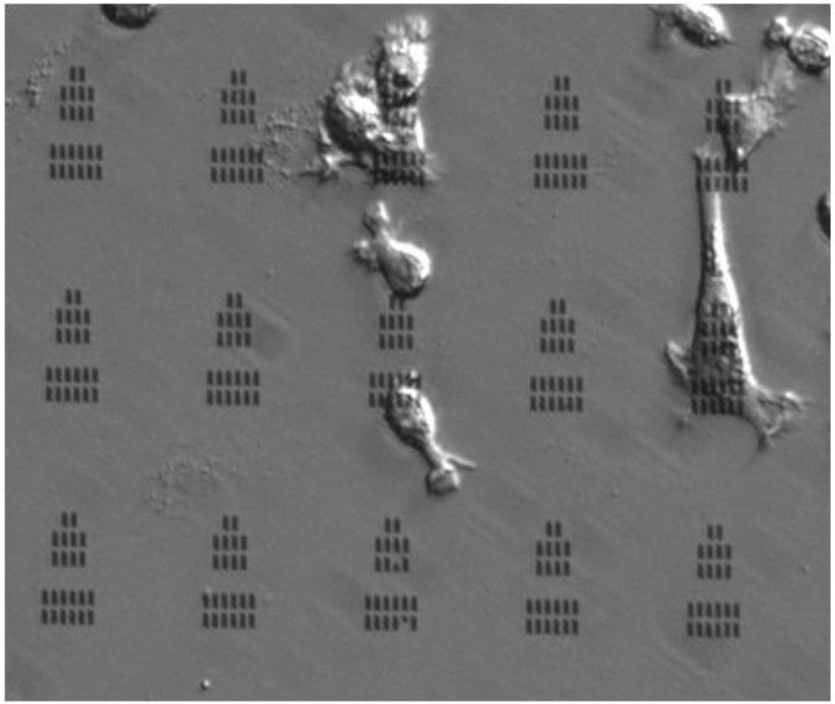
But the change of paradigm comes with the concept of Tissue Engineering and later Regenerative Medicine. The increasing knowledge and control on stem cells opens a whole new future and demands on biomaterials.

The new demands may range from those requested in drug or gene delivery to those simulating the extra cellular matrix for scaffolds in tissue engineering or regenerative medicine. These demands are usually highly different from those requested for implants as those just described.



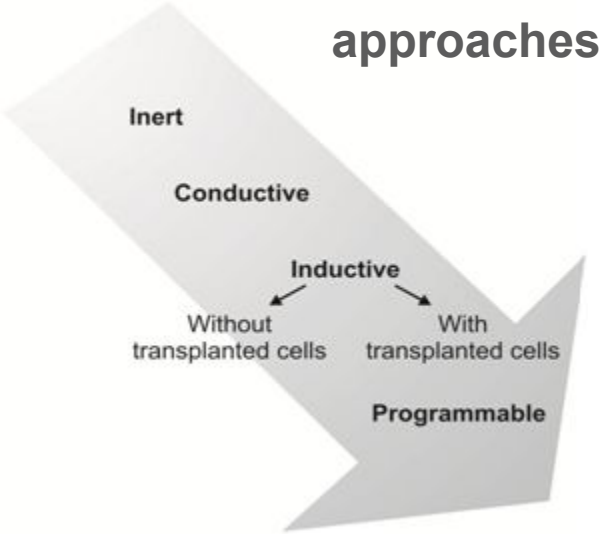


New knowledge on biochemical and physical signaling and nanotechnology have become two major players in the field

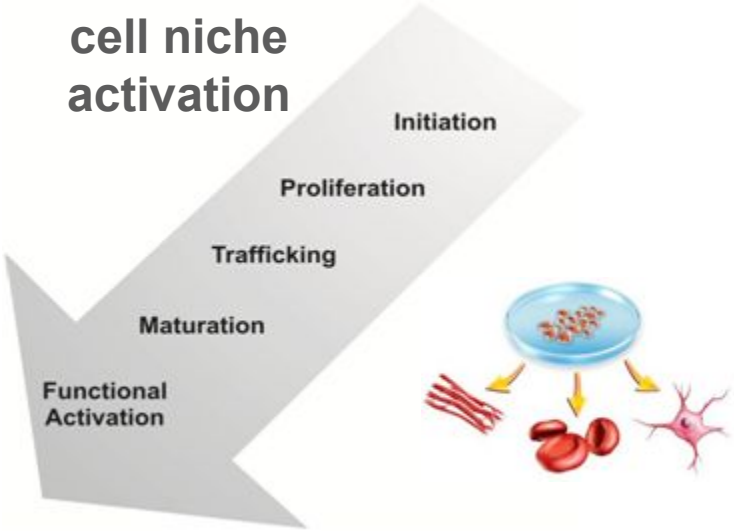


Regenerative medicine: Biomaterials and Biology at the interface

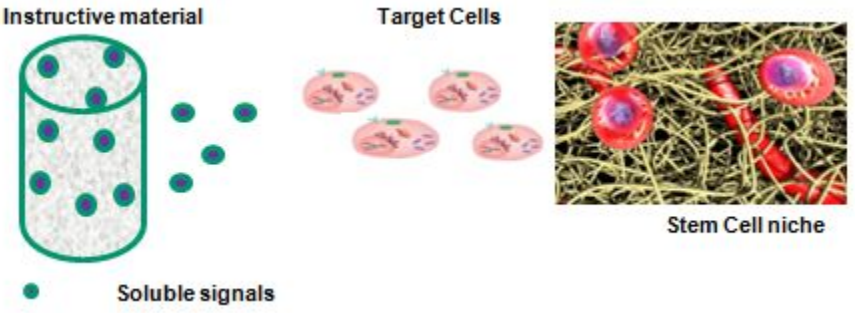
Evolution of biomaterials approaches



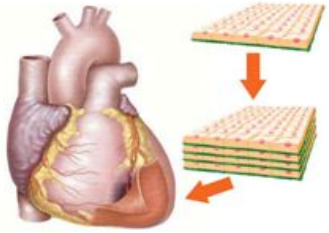
Phases of stem cell niche activation

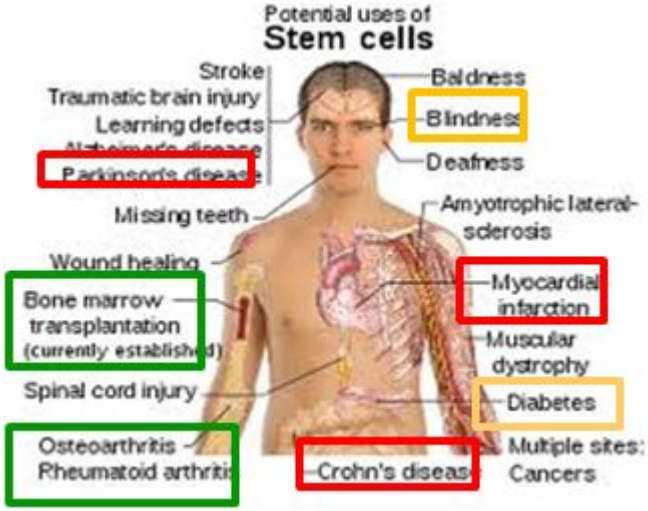


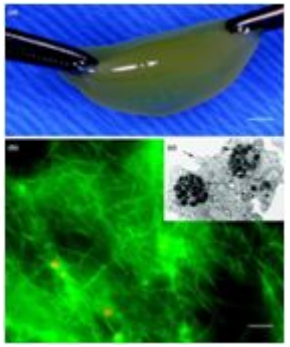
Instructive Materials as a factor to program stem cells



Strategies of the Applications

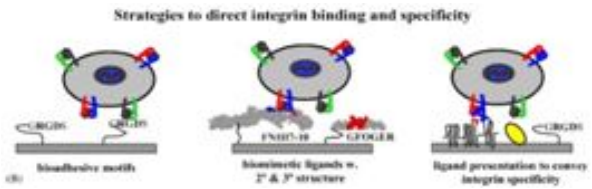


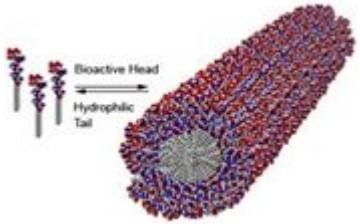


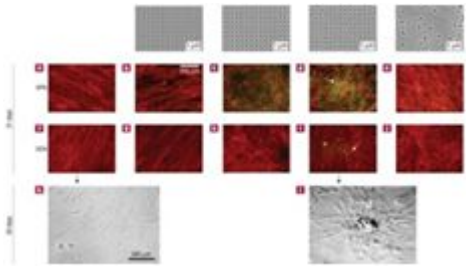


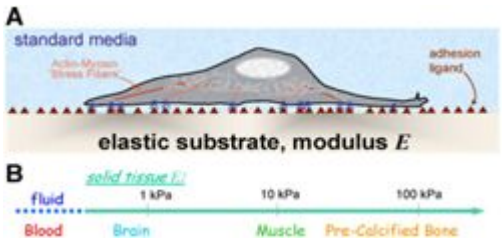
Guiding Cell Behavior

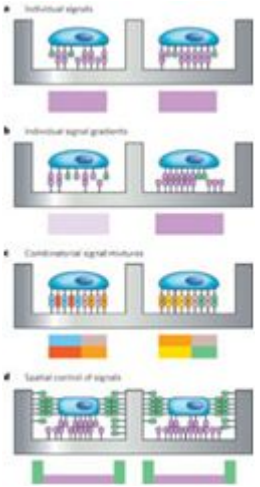
Current State of the Art Basic Research











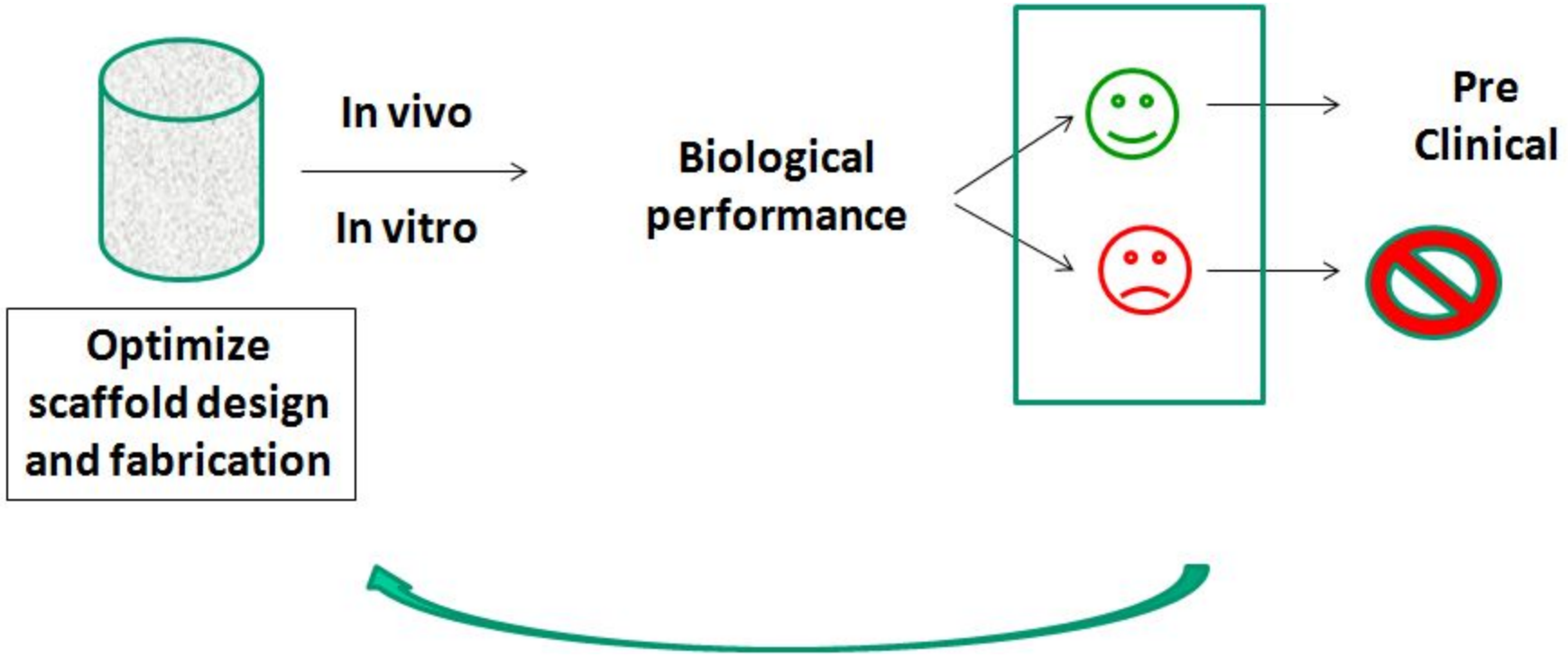
Challenges:

- Interdisciplinary basic research
- Implants development and improvement
  - Biomaterials: low added value
  - Regulations
- Cost efficiency

MOTO: We have many answers and very few good questions (Mario Barbosa)

Biology feedback to biomaterials fabrication

There is a lack of understanding on cells-materials interactions



Historical evolution of the research group

Metals, alloys and PMMA bone cements

Prof. F. Javier Gil
Technical University of Catalonia
Metallurgist, Dental Materials, Shape memory alloys, Surface Functionalization

Dr. Conrado Aparicio
University of Minnesota

Dr. José M. Manero
Technical University of Catalonia

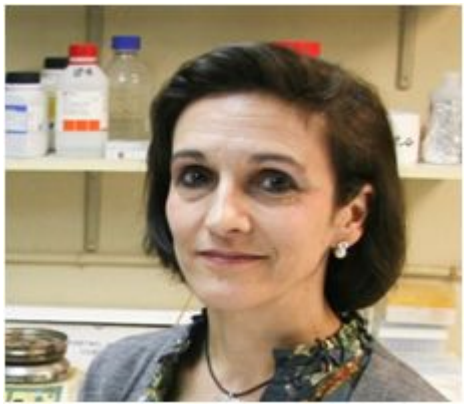
Dr. Daniel Rodríguez
Technical University of Catalonia

Dr. Maria M. Vila
Solvay Química S.L.

Calcium phosphate bone cements

Prof. Ferdinand Driessens
University of Nijmegen
(R.I.P.)

Prof. M. Pau Ginebra
Technical University of Catalonia
Calcium phosphates and
calcium phosphate bone cements

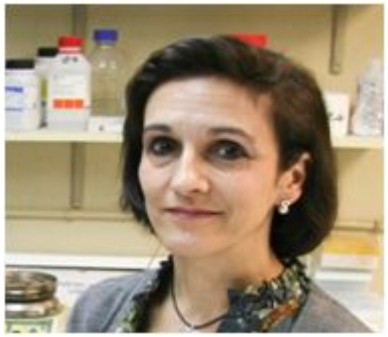


Dr. Enrique Fernández
Technical University of
Catalonia
Jean Leray award 2000

Dr. Ibrahim Khairoun
University of Nantes

Dr. Oscar Bermúdez
University of Cauca, Colombia

Calcium phosphate glasses and biodegradable composites



Prof. M. Pau Ginebra
Technical University of Catalonia
Calcium phosphates and
calcium phosphate bone cements

Dr. Melba Navarro
Chemical Engineer
Institute for Bioengineertng of Catalonia

Dr. Oscar Castaño
Inorganic chemist
Institute for Bioengineering of Catalonia

Dr. Montserrat Charles-Harris
Neos Surgery S.L.

Dr. Jérôme Clément
Velcro Europe S.A.

Computer Modeling

Prof. Damien Lacroix
University of Sheffield
Computer modeling, mecanotransduction and biomechanics
Jean Leray award 2010

Dr. Jérôme Noailly
Institute for Bioengineering of Catalonia

Biology and surface functionalization

Dr. Elisabeth Engel
Cellular Biologist
Group Leader at the
Institute for Bioengineering of Catalonia

Dr. Aitor Aguirre
Salk Institute (San Diego)

Dr. Miguel A. Mateos
Organic chemist
Institute for Bioengineering of Catalonia

Dr. Soledad Pérez
Biologist
Institute for Bioengineering of Catalonia

Materials:

- PLA, PLGA, other biodegradable polymers
- CaP glasses and vitroceramics

Fabrication techniques:

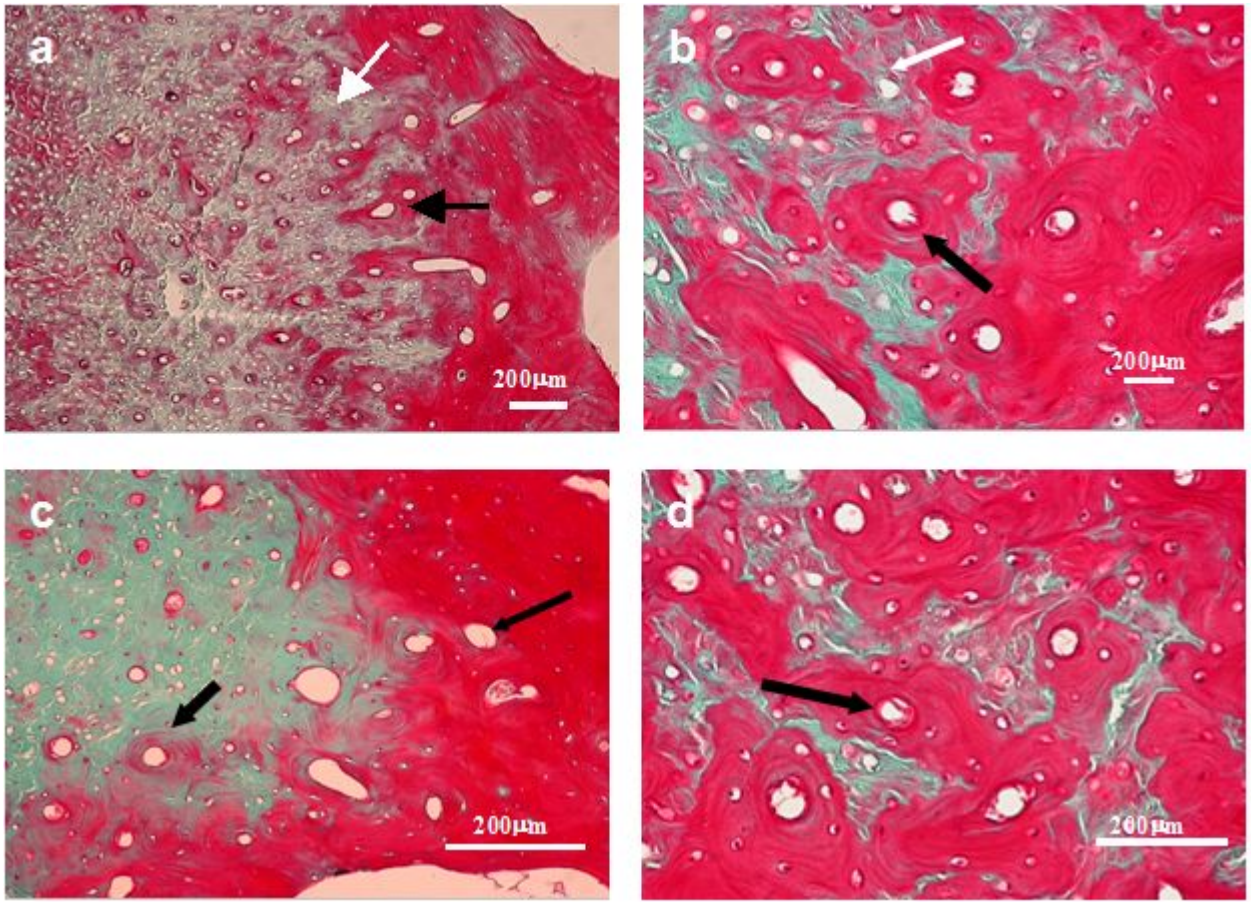
- Rapid Prototyping
- Electro spinning
- Micro/nano particles
- Sol – gel glasses
- Vitroceramics
- Composites/hybrids

Surface functionalization/modification:

- Surface Chemical Modification
  (Proteins, short peptides, ELPs, etc.)
- Surface Topography

Applications:

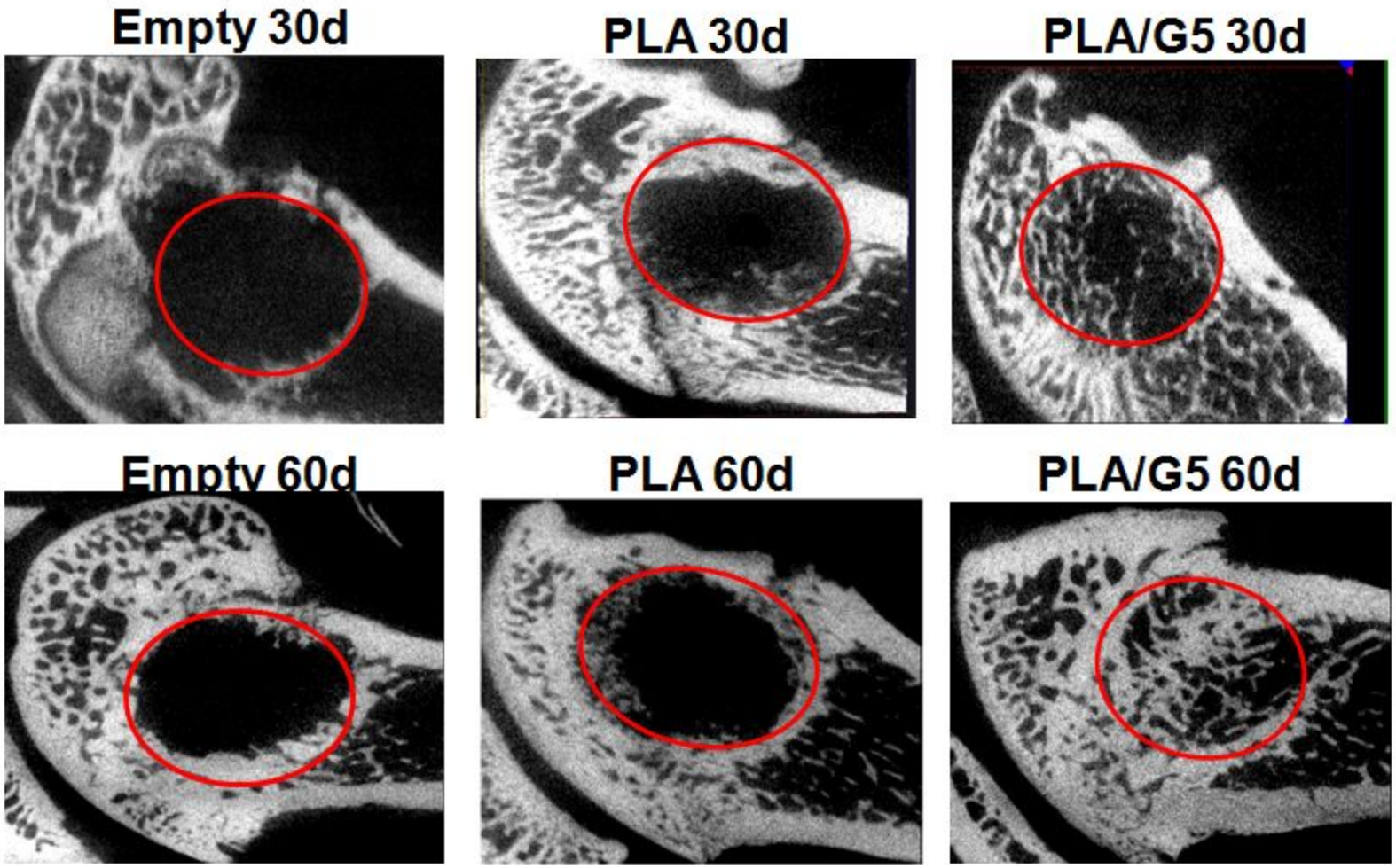
- Bone; Neuro; Vascular; Cardio; Skin



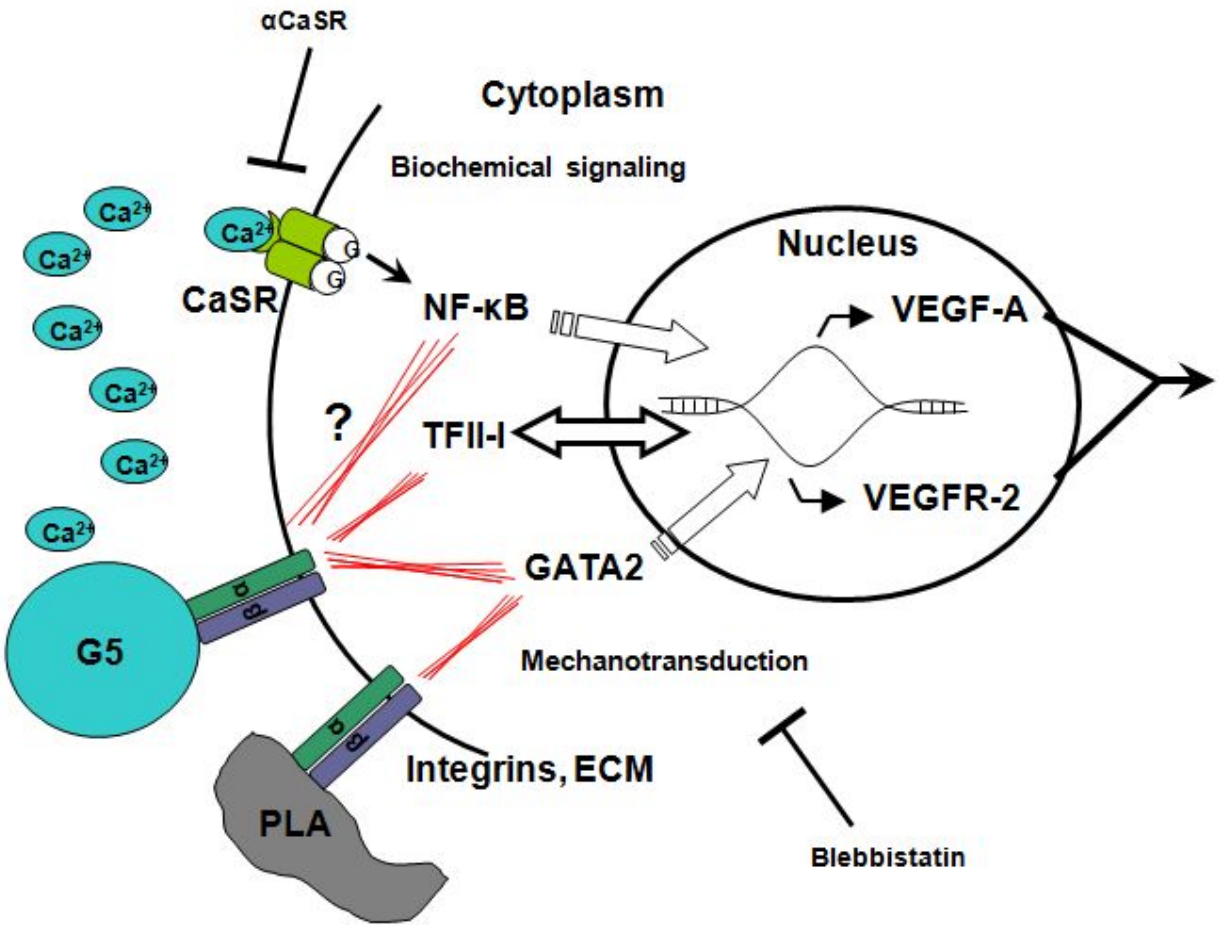
Implantation in rabbit femur

Bone defect 6mm, right distal femoral methaphysis

Histological sections stained with Goldner Tricromic obtained for G0 (a,c) and G5 (b,d) after 12 weeks of implantation. White arrows indicate glass particles, black arrows indicate osteons.


Empty 30d
PLA 30d
PLA/G5 30d
Empty 60d
PLA 60d
PLA/G5 60d

Model integrating biochemical and mechanical signals involved in PLA/G5-mediated EPC differentiation

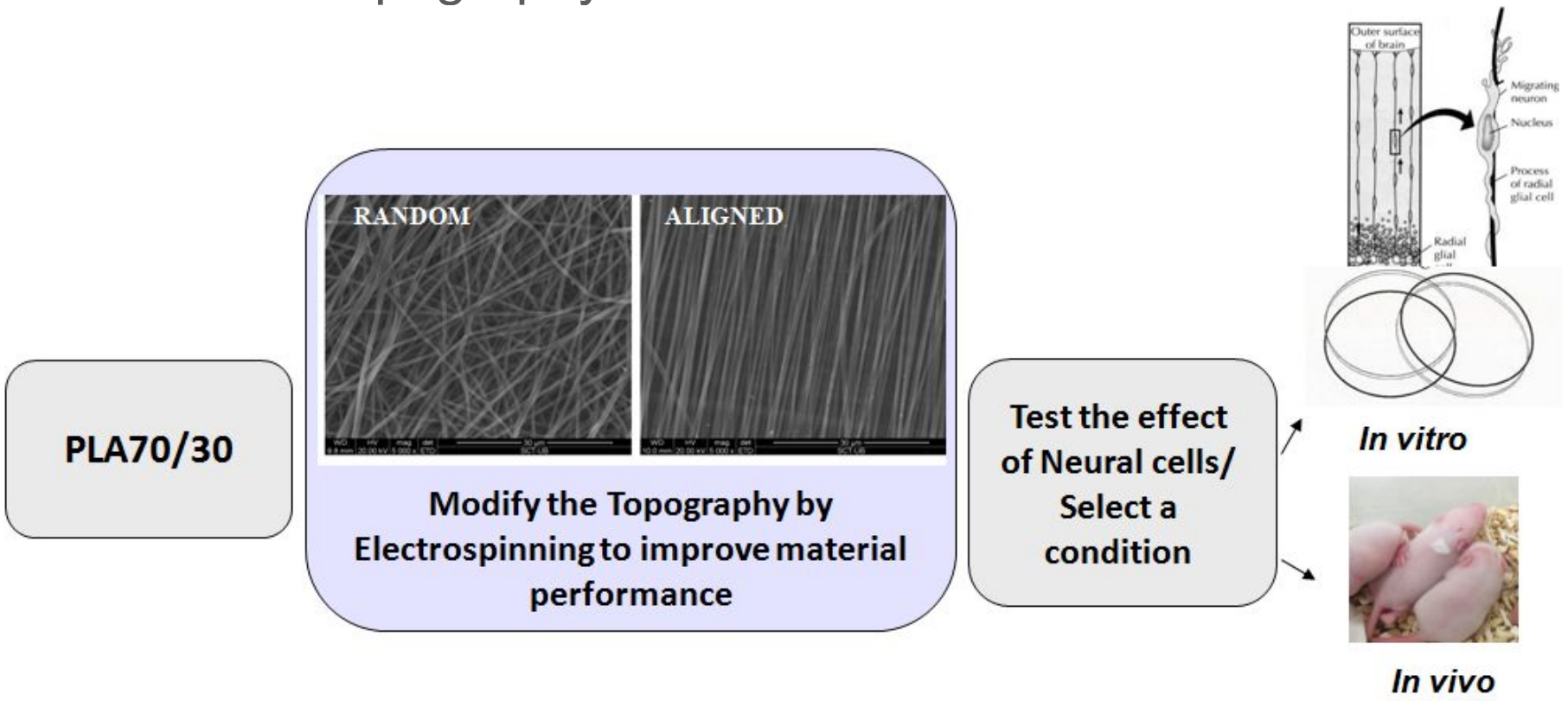


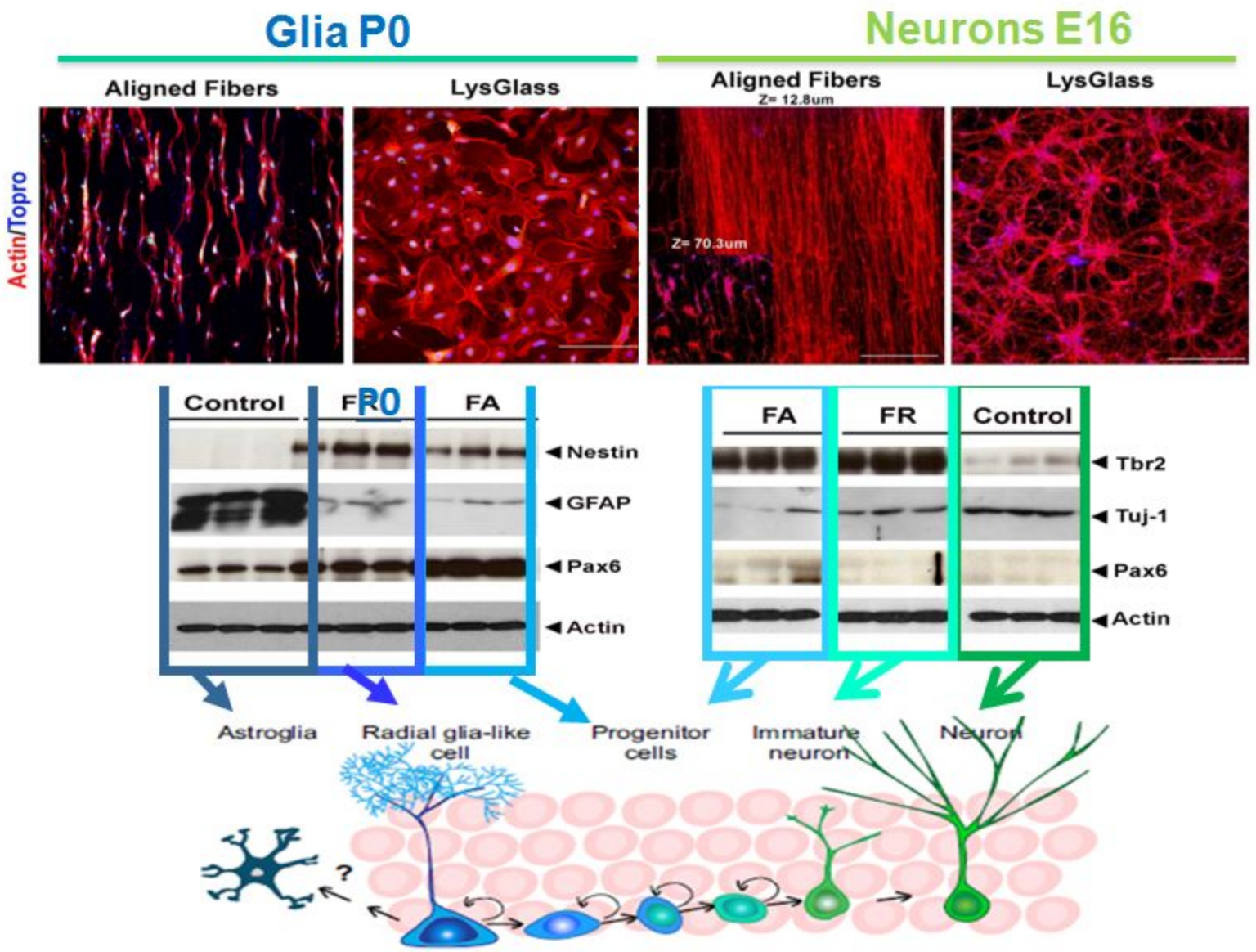
A. Aguirre, et al., European Cells and Materials, 2012

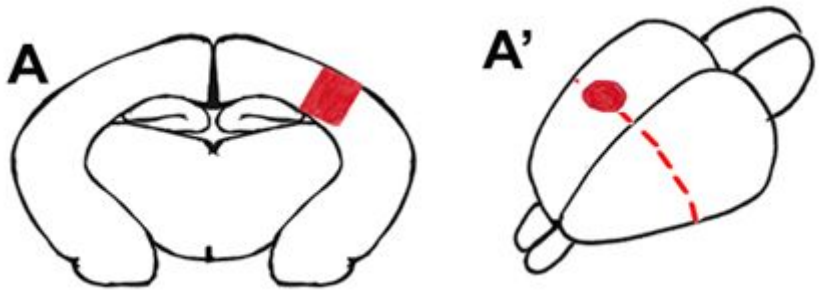
Why PLA70/30?

1. Induced a more undifferentiated phenotype of Neurons and glial cells.
2. Promoted an environment rich in progenitor cells.

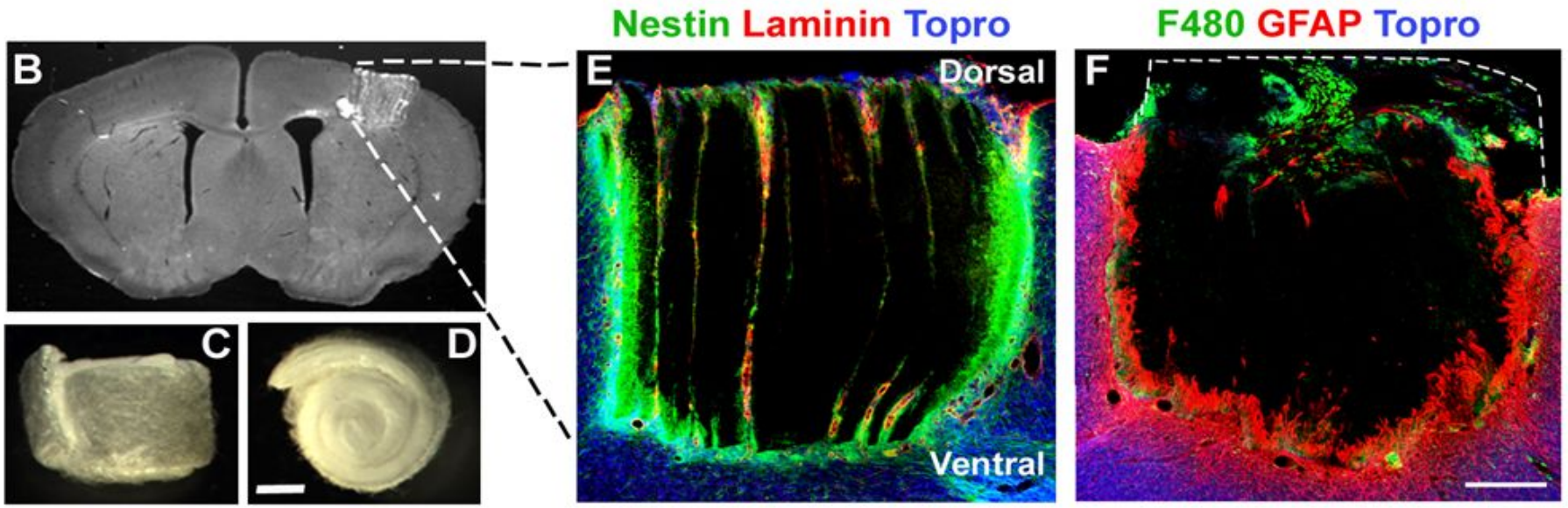
Select a Topography



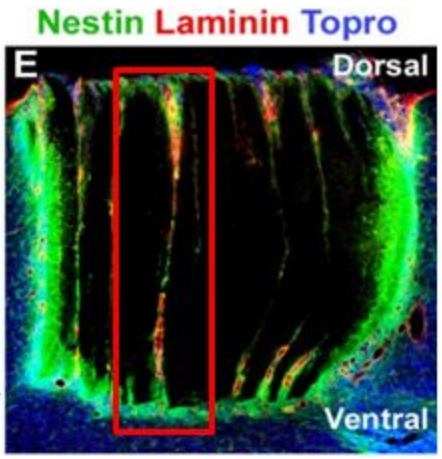

Glia P0
Neurons E16
Aligned Fibers
LysGlass
Aligned Fibers
Z= 12.8um
LysGlass
Actin/Topro
Z= 70.3um
Control
FR
FA
P0
Nestin
GFAP
Pax6
Actin
FA
FR
Control
Tbr2
Tuj-1
Pax6
Actin
Astroglia
Radial glia-like cell
Progenitor cells
Immature neuron
Neuron
?



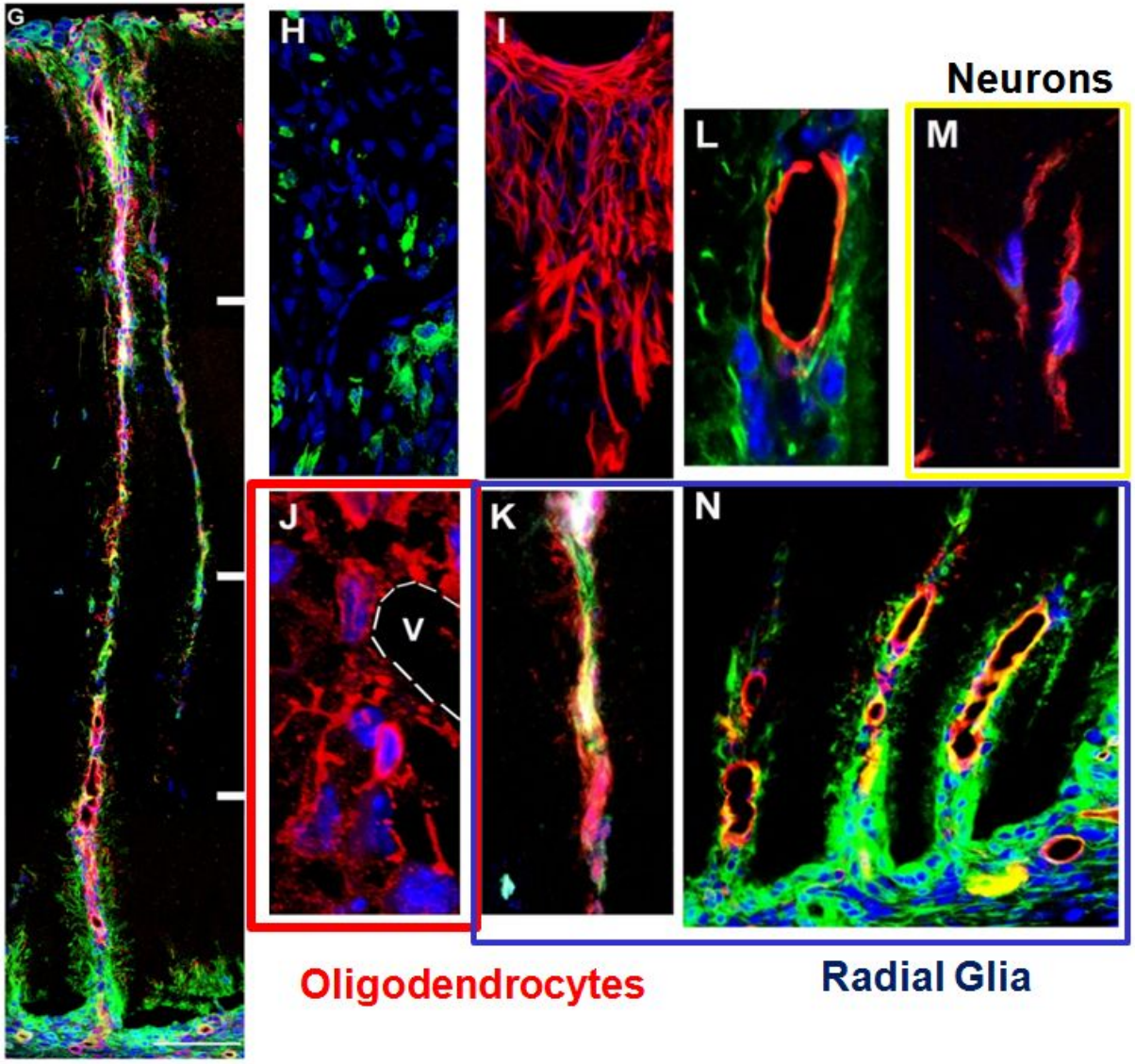
7 days post-implantation



Scaffolds were not encapsulated by a scar and did not seem to have elicited a foreign body reaction.



Radial cells migrate inside the scaffold and reconnect with cells from the ventral zone of the cortex.

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ESB
Conference on Biomaterials
including the Second Young Scientists Forum
11-14 September 2002 BARCELONA

Moltes Gràcies!!
Muchas Gracias!!
Thank you!!
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