

IBEC ANNUAL REPORT

2011



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Introduction

“

I truly believe the support structure at IBEC is probably the best in the whole Catalan research system, and possibly even in the Spanish one.”

– Josep A. Planell



The high point of 2011 at IBEC was our tremendous success in the Ministry of Science and Innovation's 'Apoyo a Centros y Unidades de Excelencia Severo Ochoa' programme, which stood testament to the strength of our institutional strategy even in the face of financially difficult times.

Aiming to identify the best research centres in the country according to scientific relevance, human resources and international competitiveness, the programme selected IBEC among the 22 centres to go through to the second round, out of a total 75 in a wide range of disciplines. This not only ranks IBEC among the 22 best evaluated research institutes in Spain, but also placed us within the top ten of the centres working in physics and engineering.

Another coup was the result of the year's International Scientific Committee meeting. Favourably impressed by their evaluations of the latest four groups to be examined, and finding their positive opinion of the overall quality of our work and strategy reinforced, the committee announced its intention to include in its final report a recommendation to the Board of Trustees to seek ways of improving our funding.

These successes were undoubtedly a direct result of the quality of research that our group leaders and their respective groups are conducting. IBEC is attaining real scientific excellence that places us amongst the best in Spain, and allows us to compete at a European and international level. However, it is also thanks to our tremendous support structure. The support services staff – in finance, HR, general and institutional projects, funding services, infrastructures, events, and communications – are not only experts, but they're totally committed to the mission and the goals of IBEC. They allow our excellent researchers to concentrate on their work, making everything else in life simpler and providing the best possible conditions for 220 scientists to achieve results that are at the frontier of knowledge. I'm tremendously proud of them, and personally believe that the support structure at IBEC is probably the best in the whole Catalan research system, and possibly even the Spanish one.

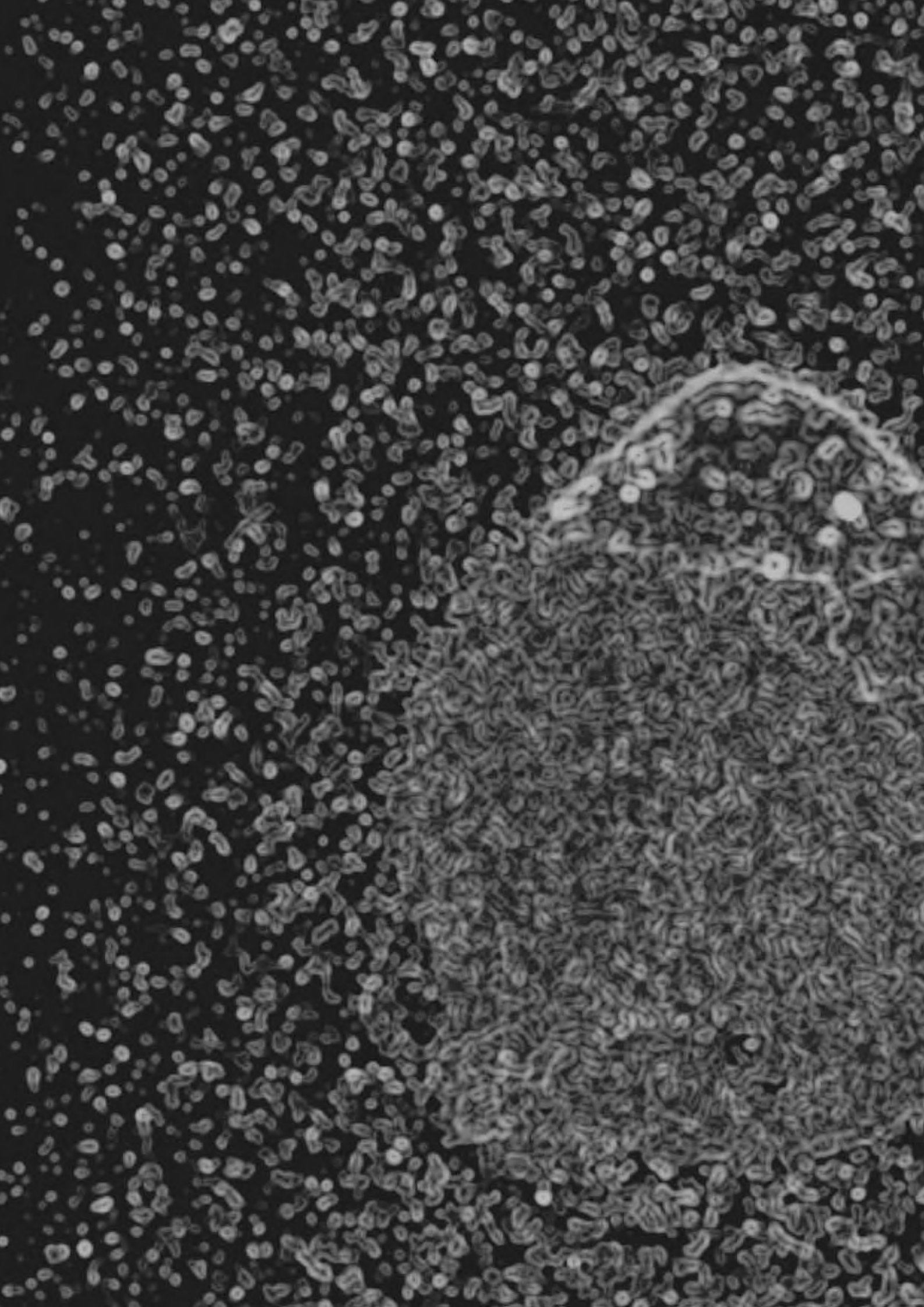
It was a year of change at various levels, with the departure of managing director Abel Riera and the arrival of his replacement, Alex de Jaureguizar. Despite the upheaval that change at the top inevitably brings, the support services team continued to work at full capacity in the face of new challenges and with unfailing loyalty to the institute. On the scientific side, we also saw Single Molecule Bionanophotonics group leader Maria Garcia-Parajo depart the institute for the more physics-based environment of ICFO, the bioengineering facet of her research having been fruitfully completed in the five years she spent at IBEC.

The current financial climate dictates that when good researchers leave, they cannot be immediately replaced, but our aim is to protect our present level of resources and capacity of work. To this end, in 2012 we will set in motion a procedure of tenure track to ensure reasonable growth by attracting outstanding young researchers to the institute, as well as leveraging the promising talent we already have. With these efforts, I believe we can expect that by 2015 our position will be extremely strong, allowing us to speed up to pole position towards the definitive growth and consolidation of IBEC.

The associate director and I are proud of all IBEC's researchers and staff, and it is a great honour and pleasure to be able to work with all of them. We'll make through the difficult times together with effort, cooperation and a lot of enthusiasm.

A handwritten signature in dark ink, appearing to read 'J. Planell', is written over a light blue grid background.

Josep A. Planell
Director of IBEC



Contents

■ 2011 in review	6-13
News highlights	6-9
Scientific highlights	10-14
■ Organisation	14-19
The IBEC private foundation	14-15
IBEC people: Faculty	16
IBEC people: Administration	17
2011 Statistics	18-19
■ Research	20-75
Cellular Biotechnology	22-31
Biomechanics and cellular biophysics	32-40
Nanobiotechnology	41-51
Biomaterials, implants and tissue engineering	52-62
Medical signals and instrumentation	63-71
Robotics and biomedical imaging	72-75
■ Networking	76-85
Partnerships	78-79
Research agreements and MoUs	80-81
Institutional initiatives and projects	82-83
Strategic alliances	84-85
■ Events and communications	86-97
Seminars and PhD Discussions	88-89
Meetings and outreach activities	90-93
Communications	94-97

2011 in review

News highlights

January

IBEC researcher receives Pablo Motos award

Eduard Torrents, senior researcher in IBEC's Microbial Biotechnology and Host-pathogen Interaction group, was announced as a recipient of the 2010 Pablo Motos award from the Federación Española de Fibrosis Quística (Spanish Association of Cystic Fibrosis) at the beginning of the year. Pablo Motos, a well-known TV personality and creator of the popular show 'El Hormiguero', donates the royalties from his book 'Frases célebres de niños' to the foundation to provide the annual prize, which aims to support research projects in cystic fibrosis or social initiatives that benefit sufferers of the disease.

Eduard's project, 'Ribonucleotide reductase: a novel therapeutic target against bacterial pathogens in cystic fibrosis patients' was one of a total of four winners chosen by the foundation from many proposals entered from all over the country. A quarter of the total prize amount will fund his work on the project for up to two years.

Kick-off meeting of the Connect-EU Nanobio+ Nanomed working group

January saw the kick-off meeting at IBEC of the Connect-EU Nanobio+Nanomed Working Group (WG). An initiative that aims to promote and reinforce Catalan participation in the EU's instruments for research funding such as FP7 and its successor, HORIZON 2020, the Connect-EU network of WGs covers a range of sectors, from the internet of the future to food technology and processing.

IBEC leads the Nanobio+Nanomed WG, which also involves as core members other centres such as ICFO, ICN, IQAC-CSIC and ICMA-B-CSIC; companies from the biotech, pharma and medtech sectors, such as Advancell and NTE-Sener; and hospitals, led by Vall d'Hebron. The WG membership reflects the multidisciplinary of

nanobiotechnologies and its many possible applications at industry level.

During the meeting, the group discussed the first steps towards its aim to provide an expert opinion on the 'hot' topics and the local strengths in the field for ACCIÓ, the agency set up by the government to make Catalan enterprise more globally competitive.

February

Nanomedicine in Spain: looking back to see forward

A 'who's who' of Spain's major players in nanomedicine and a record of this new field's most notable achievements, "Nanomedicine in Spain 06-10", was launched in February.

The report, which was coordinated by IBEC as leader of the Spanish Nanomedicine Platform (NanoMed Spain), covers the creation of large research initiatives such as CIBER-BBN, public-private collaboration, international consortia such as BOND and Lymphotarg and entrepreneurship activities fostered by the Platform. As a reference work for this emerging area, it aims to provide an overview of nanomedicine's formative years for policy makers, industry associates and existing stakeholders, as well as those looking to enter the field.

The document was presented at the one-day workshop 'Nanomedicine in Spain: present and future' at the Center for Industrial Technological Development (CDTI) in Madrid, chaired by M^a Luisa Castaño, Deputy Director General of Strategic Public-Private Cooperation (MICINN). The workshop also featured presentations by some top researchers in nanomedicine to foster an open debate on Spain's strengths in this emerging sector and the key technologies to focus on in the next few years.

Think Lab

In February IBEC joined forces with Barcelona's Arts Santa Monica centre and the British Council for a special activity



Meeting of the Connect-EU working group; Funding from RecerCaixa for photopharmacology project; Public presentation of BioNanoMed Catalunya

looking at the research laboratory from a cultural point of view.

Within the framework of the centre's 'Think Art, Act Science' exhibition, 'Think Lab' comprised two workshops, a round table debate and a performance. All took a look at the lab as a cultural phenomenon, concluding that as a place for experimentation, for trial-and-error hypothesizing, for creating knowledge through experience and for opening the door to future innovation, a multidisciplinary and international scientific laboratory has a spirit and a dynamic that shares much with culture as a whole.

Later in the year this arts and science initiative was awarded the Antoni Caparros Prize for Best Knowledge Transfer from the University of Barcelona.

Funding from RecerCaixa for photopharmacology project

ICREA group leader Pau Gorostiza's project 'Development of light-modulated ligands for remote, non-invasive regulation of neuropathic pain' was announced as one of the first twenty projects to be chosen for funding by a brand new programme, RecerCaixa.

A joint initiative by the Associació Catalana d'Universitats Públiques (ACUP) and Obra Social la Caixa, RecerCaixa has earmarked €9m for the period 2010-2014 to finance research projects selected for their scientific quality. The first twenty, which were chosen from 461 hopefuls, focus on health sciences, particularly public health, and social sciences to do with education and immigration.

Pau's project goes deep into the new pharmacological concept of light-controlled drugs (photopharmacology), including how to regulate their effectiveness and the spatial and temporal distribution of their physiological effects. It's hoped that the results of this study will be relevant to personalised medicine and the development of patient-specific therapies.

This was the second major project involving Pau who, alongside Fausto Sanz, heads IBEC's Nanoprobes and Nanoswitches group. In January the collaborative project Single Molecule Activation and Computing (FOCUS), in which he is a partner, was awarded funding by the EU for its work on

building a next generation of biologically inspired molecular devices based on new photonic tools.

May

Public presentation of BioNanoMed Catalunya

A press conference to present BioNanoMed Catalunya, the IBEC-led alliance created to promote nanotechnology applied to healthcare and biotechnology, was held in May at the Museu Colet in Barcelona.

BioNanoMed Catalunya brings together 18 research centres, hospitals and companies to share know-how and resources, facilitate new developments in nanomedicine and gain international visibility for the advances in nanotechnology that are emerging in Catalonia. Along with Biocat, the Catalan Bioregion agency, IBEC has been developing the initiative since 2009. Among the 37 research groups involved in the alliance are IBEC's Bio/Non-bio Interactions for Regenerative Medicine, Cellular Biomechanics, Nanobioengineering, and Nanoprobes and Nanoswitches groups.

The network's first public activities included a presentation at the EuroNanoForum at the end of May in Budapest and participation in Washington's BIO Convention in June.

ERC Starting Grant for IBEC researcher

Biomechanics and mechanobiology group leader Damien Lacroix was awarded a prestigious European Research Council (ERC) Starting Grant for his research on finite element simulations of mechanobiology in tissue engineering.

With the funding, which will be supplied for up to five years, Damien will attempt to reach new frontiers in mechanobiology with the development of a novel approach for the modelling of tissue engineering. By integrating the microscopic modelling of cells with the macroscopic modelling of scaffolds, this research will shed light on the influence of

News highlights *continued*

mechanical loading and stimuli on cell behaviour and the subsequent formation of tissues.

Damien is the third IBEC researcher to win one of these highly sought-after grants, about 250 of which are awarded each year to EU-based researchers with talent and proven potential. In the last call, nearly 4100 proposals were submitted. In 2008 Pau Gorostiza, group leader in IBEC's Nanoprobes and Nanoswitches group, received an ERC Starting Grant, as did Xavier Trepatri in 2009.

July

IBEC passes the first stage of Severo Ochoa

IBEC was one of 22 centres, covering a wide range of disciplines, out of a total of 75 to be selected to go through to the second stage of the Ministry of Science and Innovation's 'Apoyo a Centros y Unidades de Excelencia Severo Ochoa' programme.

The programme, which was launched by the MICINN in April, aimed to identify the ten best research centres in the country according to scientific relevance, human resources and its international competitiveness. Successful centres, which are selected by a committee of international investigators and Nobel Prize winners, receive a million euros annually for four years, preferential access to scientific installations and flexibility in the contracting of researchers.

October

'Roadmap' for nanobiotech in Catalonia presented

The IBEC-coordinated Connect-EU Nanobio + Nanomed working group published a 'roadmap' for nanobiotechnol-

ogy capabilities in Catalonia, the first major step since the group's launch at the end of last year.

The document, "Connect-EU Nanobio + Nanomed Strategic Research Agenda" was presented at the annual forum of the European Platform on Nanomedicine (ETPN), which followed the 4th IBEC Symposium at the Hospital de Bellvitge. As well as providing a plan for this strategic area of knowledge in the region, the publication aims to help define priorities in innovative applications for the pharmaceutical, medtech and environmental industries that can be transformed into European projects under the EU's FP7 funding programme and its continuation, HORIZON 2020.

November

IBEC students' PhD programmes get top billing

The Spanish Ministry of Education published the list of doctoral programmes that have received the accreditation of "Mention of Excellence". Among them were all the main doctoral programmes open to IBEC PhD students from the University of Barcelona (UB) and the Universitat Politècnica de Catalunya BarcelonaTech (UPC).

Programmes receiving this quality award have achieved the highest marks in a rigorous selection process, and are recognised as international benchmarks in their fields. Criteria taken into account in order to achieve this ranking include publication records, the programme's ability to attract students from other universities and nationalities, possibilities for mobility and placements abroad, and participation in competitive research.

The awarded programmes included Biomedicine, Biotechnology, Nanoscience and Nanotechnology, and Engineering and Advanced Technologies (UB), and Biomedical Engineering, Materials Science and Engineering, and Automatic Control, Robotics and Computer Vision (UPC).

La Marató de TV3 2010 funds awarded

The 55 researchers who received funding from fundraising programme La Marató de TV3 2010, including IBEC's Pau Gorostiza, attended a ceremony at the UAB where the grants were awarded in the presence of Minister of Health Boi Ruiz, Rector of the UAB Ana Ripoll, and La Marató de TV3 founder Enrique Marin.

Pau's project with Dr. Artur Llobet Berenguer of IDIBELL, "Regeneració de circuits neuronals mitjançant marcapassos optogenètics", receives almost €300,000 of the €7.7m total raised by the 2010 edition of the fundraising show. It will set the basis of a novel pharmacological approach to neuronal regeneration by defining a proof-of-principle based on optogenetics and photopharmacology.

December

Funding success for two IBEC projects

Towards the end of the year, two IBEC-led tissue regeneration projects were selected for funding by the EU's ERA-NET EuroNanoMed initiative.

'Angiogenic nanostructured materials for non-consolidating bone fractures' (nAngioFrac), coordinated by Josep Planell's Bio/non-bio Interactions for Regenerative Medicine group, brings together four other academic, clinical and industrial partners from France and Poland. It aims to develop tailored biodegradable and bioactive nanostructured scaffolds to ensure the correct release of calcium, a major player in angiogenesis (the formation of new blood vessels), to promote tissue repair in pseudarthrosis. This condition results from inadequate healing after a bone fracture and sometimes during development, and results in a 'false joint'.

The second project, 'Nanostructured Gel for Cellular Therapy

of Degenerative Skeletal Disorders' (STRUCTGEL), will be coordinated by Molecular Dynamics at Cell-biomaterial Interface group leader George Altankov and involves partners from Germany, France and Turkey. With the aim of tackling degenerative skeletal tissue disorders such as osteoarthritis and osteoporosis, the consortium will combine high performance materials and advanced nanotechnology to design an implant with unique properties which can influence site-specific tissue regeneration.

Under the ERA-NET scheme, projects are evaluated by a centralized selection committee, but each partner of the project is funded by its own country of origin. Therefore, although the EuroNanoMed projects have already been selected, before starting, these projects had still to go through ad-hoc national calls.

IBEC/UPC spin-off for surgical robotics

A new spin-off company created by IBEC and the UPC will focus on the manufacture and marketing of surgical systems.

Rob Surgical Systems Inc., a technology company driven by IBEC group leader Alicia Casals and senior researcher Manuel Frigola, as well as Josep Amat of the Automatic Control and Computer Engineering Department of the UPC, was approved by the university's governing council in December.

The company will manufacture the systems that IBEC's Robotics group has been developing in recent years. The first product will be a minimally invasive robotic station, Bitrack, which has advantages over those currently on the market since it occupies less space in the operating room. Its specially adapted user interface also enables a faster start-up, reducing the cost of interventions.

The new company will validate the initial prototype of Bitrack and obtain the certifications necessary to start marketing it in Europe and the United States. Rob Surgical Systems already has the support of the medical direction of the Mayo Clinic in Phoenix, Arizona, and aims to look for other alliances to expand the market.

IBEC passes the first stage of Severo Ochoa; 'Roadmap' for nanobiotech in Catalonia presented; IBEC's Robotics group



2011 in review

Scientific highlights

January

Joining the fight against malaria

At the beginning of the year the Nanobioengineering group published a description in *J. Control Release* of a nanovector able to discriminate between blood cells infected with *P. falciparum*, the parasite that causes the most severe form of malaria, and non-infected cells for targeted drug delivery.

Current methods of administering antimalarial drugs deliver compound into the blood stream, where it can be taken up by all cells and not only by infected ones. The group used fluorescence microscopy to assess the efficiency of nano-sized liposomes, or carriers, which had been covalently functionalized with oriented, specific half-antibodies against late-form *P. falciparum*. They found that these 'immunoliposomes' docked to late-form infected membranes in 100% of cases, and not at all to non-infected cells.

With such a specific method of delivery, drug dosage could be adjusted to a low overall concentration, while still offering a guaranteed localized delivery of highly toxic doses only to parasitized cells. The findings also mean that existing drugs that are not being tested because of their high toxicity or elevated unspecificity may be used.

reveals differences between the reduced and oxidized states of a protein, that may be relevant to the control of ET rates in enzymes and biological electron transport chains.

"Methods to measure ET at the single-molecule level will help resolve temporal variations in enzyme activity that can be correlated with conformational changes to allow the ultimate miniaturization of nanodevices," explains group leader Pau Gorostiza.

The group also participated in a project led by researchers at the Institute for Materials Science of Barcelona, in which they characterized a robust molecular switch in solution that operates at very low voltages, can be 'patterned' by electrical input and has exceptionally high long-term stability, reversibility and reproducibility. "This switch is a very promising platform for use in memory devices," says Pau. These results were published in *Nature Chemistry* in March.

Intelligent design

Researchers in the Biomechanics and Mechanobiology group published a study in *Biomaterials* in February that revealed how the design of tissue engineering scaffolds can influence the distribution of adhering cells after perfusion cell seeding.

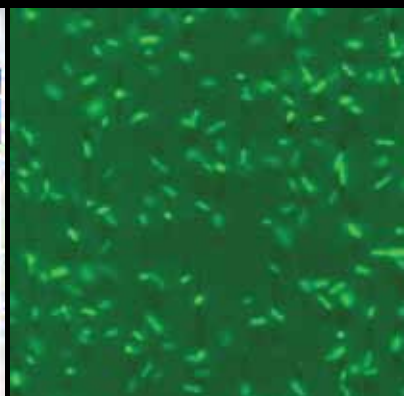
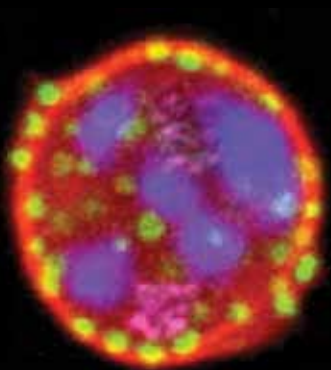
In designed porous structures, the ability to influence the distribution of seeded cells is fundamental to allow the controlled engineering of complex 3D tissue structures in specific shapes. Together with collaborators in the Netherlands and Switzerland, the scientists described a model system that assesses the influence of local fluid flow characteristics in designed porous scaffolding structures on the distribution of cells upon seeding. They found that the density of adhering cells correlates to the local average wall shear rate at the surface of the pore walls. While scaffolds with an isotropic gyroid pore network architecture show very homogeneous distributions of shear rates and cell densities after seeding, gyroid scaffolds prepared with gradients in pore size and porosity show anisotropic adherent cell densities. The highest cell densities in the scaffolds could be related to regions with larger pores, higher fluid flow velocities and higher wall shear rates.

February

Two papers for Nanoprobes group

IBEC researchers found a way to measure the rate of electron transfer (ET) – an important process which is essential in many chemical and biological processes such as cellular respiration and photosynthesis – at the single-molecule level.

In a study published in *ACS Nano*, members of the Nanoprobes and Nanoswitches group described how they used an electrochemical tunneling microscope to measure the 'distance decay constant' that characterises the rate of ET in redox proteins. Analysis of decay constant measurements



Confocal fluorescence microscopy study of the subcellular localization of monoclonal antibody BM1234 in *P. falciparum*; "We're made of glass" in *El Mundo*; Green fluorescence protein expression under the *nrdAB* promoter region in *P. aeruginosa*.

March

Electromechanics at the nanoscale

Flick a switch, turn a knob or pull a lever and you're operating an electromechanical device, albeit a complex one. In March an IBEC researcher and his collaborators broke new ground with a proven concept for the first such electronic component to operate using just a single-molecule electrical contact.

In a study published in *Nature Nanotechnology*, Ismael Díez Pérez, a researcher in IBEC's Nanoprobes and Nanoswitches group, and Nongjian Tao from Arizona State University described their success in attempting to find a way to simulate the same electromechanical effects achieved on conventional electronics, but in a single-molecule device that allows the accurate mechanical control of the current flow. Such devices would open up huge possibilities in being able to create things at an ever-smaller scale.

We're made of glass, say scientists

People can be brittle, transparent, shattered, or have a heart of glass. In March these attributes seemed all the more appropriate following a discovery by researchers that migrating cells in our bodies behave in a remarkably similar way to glass when it is heated and cooled.

In a study published in *PNAS*, IBEC's Xavier Trepas and his collaborators discovered that the movement of a collection of migrating cells is similar to a process called glass transition. Glass is, by definition, a non-crystalline solid that goes from brittle to molten when heated, and the other way around when cooled: this is glass transition, one of the great unsolved problems in physics. "Our results provide a startling analogy," says Xavier. "It had been predicted that over certain time scales, tissues might flow like fluids. What we've found shows that if cell density is below a certain amount,

then confluent cells (cells that move together) indeed flow like a fluid. However, as density increases, the collective dynamics of the cells progressively slow down, much as the molecules of molten glass slow down as it is cooled."

A glass-like behaviour of confluent cells has direct implications on collective cell migration and its purposes, so this new knowledge provides a framework for understanding the dynamics of wound healing or the metastasis of cancer cells.

April

Opening new doors to combat bacterial infections

We may be several steps closer to understanding one of the major pathologies that affects sufferers of cystic fibrosis, thanks to senior researcher Eduard Torrents of IBEC's Microbial biotechnology and host-pathogen interaction group.

In a study published in April in the American Society for Microbiology's journal *Infection and Immunity*, Eduard and his collaborator in Stockholm, Britt-Marie Sjöberg, looked at DNA synthesis in *Pseudomonas aeruginosa*, a bacterial infection that is a frequent complication in many people with cystic fibrosis, and a common cause of death in those patients. Focusing on ribonucleotide reductase enzymes, which are essential for cell division with a high fidelity duplication of DNA – a critical step in the life cycle all types of organisms – the researchers studied the expression of each of these type of enzymes during aerobic and anaerobic growth of *P. aeruginosa* and their role during infection.

"Ribonucleotide reductases control the only pathway to the deoxyribonucleotides which are required for DNA synthesis and repair," explains Eduard. "By studying them, we were able to examine the shift in expression of each during the infection process and so determine which ones in particular could be considered a good target to inhibit the growth of *P. aeruginosa* in chronic cases."

Scientific highlights *continued*

May

Plithotaxis: how crowds of cells find their way

IBEC's Integrative Cell and Tissue Dynamics group collaborated with Harvard investigators to come up with a brand new concept in biology, plithotaxis.

In the journal *Nature Materials* in May, IBEC group leader Xavier Trepas, together with Harvard researcher and IBEC ISC member Jeffrey J. Fredberg, shed light on how cells move within a monolayer cell sheet to enable the whole to migrate. "We'd long suspected that each cell exerts force not only upon its extracellular matrix but also upon neighbouring cells," explains Xavier. "Plithotaxis, which comes from the Greek *plithos*, meaning swarm, describes what we discovered when we devised a way to measure these forces: that each cell pushes and pulls on its neighbours in a chaotic 'dance', yet moving the whole cooperatively in its intended direction."

The discovery of a relationship between physical forces and individual cellular motions *in vitro* demands further tests to see whether it holds in *in vivo* tissues, and could open new avenues in predicting the movement of cancer cells.

was achieved by mimicking embryonic development of the hematopoietic system. The group's new protocol is much more robust and efficient than previous methods.

Identifying an essential interaction for epilepsy

In June scientists at IBEC described a major step towards understanding epilepsy in a paper published in *Molecular Biology of the Cell*.

The researchers shed new light on the importance of a neuronal protein known as PrPc. When mutated or misfolded, its pathogenic form induces progressive conditions that affect the brain and nervous system, such as Creutzfeldt-Jakob disease and BSE. In epilepsy, it appears that the healthy protein plays a preventative role.

"PrPc's modulation of GluR6 activity plays a key role in the activation of the pathway that leads to the disease," explains Patricia Carulla of IBEC's Molecular and Cellular Neurobiotechnology group. "PrPc in the neuron blocks the GluR6 receptor. Absence of PrPc, however, allows the formation of this three-molecule receptor complex which in turn leads to activation of the JNK3 pathway, resulting in increased epilepsy and cell death in the hippocampus."

The group is now speculating that a similar protective effect of PrPc may occur in other brain injuries sharing a similar activation mechanism where signalling is transmitted downstream via GluR6 to the JNK3 pathway. Increased levels of PrPc has been found in stroke patients, for example.

June

Turning skin into blood

In June, the Control of Stem Cell Potency group published a new, highly efficient protocol in the journal *Stem Cells* for generating multipotent hematopoietic progenitors from human pluripotent stem cell (iPSC) lines. iPSCs hold huge potential for the treatment of diseases thanks to their patient specificity and their similarity to embryonic stem cells, and the ability to generate hematopoietic cells from patient-derived iPSCs enables the generation of an unlimited supply of transplantable cells for the potential treatment of hematological disorders.

The new protocol, which was developed in collaboration with Inder Verma's lab at the Salk Institute, La Jolla, CA,

August

Researchers shed new light on predicting spinal disc degeneration

In August IBEC researchers took a big step towards understanding one of the most common and debilitating complaints in the industrialized world, lower back pain, with

results that could help to predict the onset of disc degeneration.

In a paper published in *PLoS Computational Biology*, they described some important findings gleaned from looking at the effect of outside influences on healthy and unhealthy discs. They showed that weight or pressure on already degenerated discs has less effect on the transport of nutrients and cell products than on healthy ones – and that changes in cell density in discs are fundamental to the process of disc degeneration.

“In a healthy disc, we see that sustained mechanical stress – which alters solute concentration – affects the transport of nutrients more drastically than in already degenerated ones, suggesting that loading in the healthy disc is important for maintaining proper metabolic balance,” explains Andrea Malandrino of IBEC’s Biomechanics and Mechanobiology group. “It’s safe to say that an alteration of cell number caused by this disturbance to the metabolic transport could result in the possible onset of disc degeneration.”

With the knowledge that both mechanical and cellular patterns contribute to maintaining a healthy condition, new avenues of research and development in the field of disc regenerative medicine have been opened up.

Offering insights into complex cell behaviour

In August Pere Roca-Cusachs of IBEC’s Cellular and Respiratory Biomechanics group and his collaborators in the US, France and Singapore revealed that an increase in the plasma membrane tension of adherent cells coordinates the activation of exocytosis and contraction during cell spreading, suggesting that cells use this tension as a global physical parameter to control their motility.

Tension in the plasma membrane is an important factor in a range of cellular phenomena, including cell migration and mitosis; however, little is known about how it regulates such processes. In a paper in *PNAS*, the researchers described how they monitored the tension in a spreading fibroblast from the initial rapid spreading phase to the subsequent contractile spreading phase, finding that this transition

between the phases is accompanied by a transient increase in membrane tension. To see if this tension increase was the signal responsible for activating the transition, they increased it artificially, causing an abrupt halt to the edge extension and an induction of exocytosis. This indicated that tension increase not only accompanies but can also trigger the transition.

Their findings highlight membrane tension as an important mechanical regulator of cell behaviour, and offer insights into the biochemical and biophysical aspects of cellular biology that contribute to a bigger picture of complex cell activity.

November

Revealing the basis of *E. coli* infection

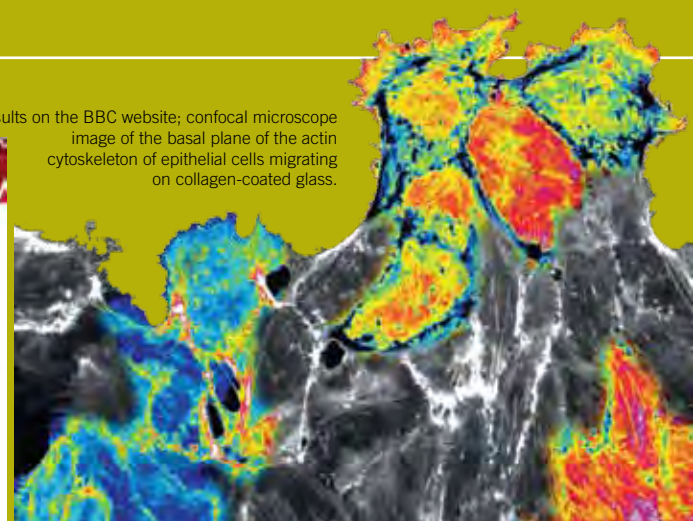
In a paper published in *PLoS Pathogens* in November, IBEC’s Microbial Technology and Host-pathogen Interaction group and their collaborators described a big step towards understanding the basis of selective regulation of virulence genes.

Their study revealed the structure of a complex between the DNA-binding domain of Ler, a master regulator of the pathogenicity island (the genetic element of an organism that is responsible for its capacity to cause disease) in virulent *E. coli* strains, and a DNA fragment.

Pathogenic *E. coli* strains carry genes acquired from other bacteria by horizontal gene transfer, and proper regulation of the correctly expressed genes is crucial for the success of the bacteria. The protein H-NS, of which Ler is a member, is a global regulator that binds DNA and keeps a large number of genes silent until they are needed.

The structure revealed by the study shows that Ler, which activates the expression of the horizontally acquired genes that are used by *E. coli* to infect human cells, recognizes specific DNA shapes, which explains its capacity to regulate genes with different sequences. This could offer insights into sustainable antimicrobial strategies that are less likely to acquire resistance.

The Biomechanics and Mechanobiology group’s *PLoS Computational Biology* results on the BBC website;





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Prof. Luigi Ambrosio

Director Institute of Composite and Biomedical Materials, University of Naples, Italy

Mr. Léonard Aucoin

President InfoVeille Santé Ltée, Canada

Prof. Paolo Dario

Director Polo Sant'Anna Valdera, Scuola Superiore Sant'Anna, Italy

Prof. Jeffrey J. Fredberg

Professor of Bioengineering and Physiology

Harvard School of Public Health, USA

Prof. Günter R. Fuhr

Director Fraunhofer Institute for Biomedical Engineering, Germany

Prof. Samuel I. Stupp

Director Institute for Bionanotechnology in Medicine, Northwestern University, USA

Prof. Bernt E. Uhlin

Professor of Molecular Biology Umeå University, Sweden

IBEC People

Faculty

Microbial Biotechnology
and Host-Pathogen
Interaction

Prof. Dr. Antonio Juárez



Nanobioengineering

Prof. Dr. Josep Samitier

Molecular and Cellular
Neurobiotechnology

Prof. Dr. José Antonio Del Río



Single Molecule
Bionanophotonics
(until July 2011)

Prof. Dr. María García-Parajo

Control of Stem
Cell Potency

Prof. Dr. Ángel Raya



Nanoscale Bioelectrical
Characterization

Dr. Gabriel Gomila

Bio/Non-Bio Interactions for
Regenerative Medicine

Prof. Dr. Josep A. Planell



Cellular and Respiratory
Biomechanics

Prof. Dr. Daniel Navajas

Molecular Dynamics at Cell–
Biomaterial Interface

Prof. Dr. George Altankov



Nanoprobes and
nanoswitches

Prof. Dr. Fausto Sanz and
Prof. Dr. Pau Gorostiza

Biomechanics and
Mechanobiology

Dr. Damien Lacroix



Biomedical signal
processing and
interpretation

Prof. Dr. Raimon Jané



Integrative Cell and
Tissue Dynamics

Prof. Dr. Xavier Trepát

Artificial Olfaction

Dr. Santiago Marco



Robotics

Prof. Dr. Alícia Casals

Directorate



Director Josep A. Planell

Associate Director Josep Samitier

Managing Director Àlex de Jaureguizar

Assistant to the Director Pilar Ciriquián

Assistant to the Associate Director Judith Forné

IBEC Administration

Support services



GENERAL PROJECTS

Head of General Projects Teresa Sanchis

Project Managers Javier Adrián, Ester Rodríguez, Juan Francisco Sangüesa, Robert Fabregat



INSTITUTIONAL PROJECTS

Head of Institutional Projects Arantxa Sanz

Project Manager Roger Rafel



INFRASTRUCTURE

Head of Infrastructure Isabel Oliveira

Laboratory Technician Laura Gómez



FINANCE

Head of Finance Ana González

Purchasing Technician Mayte Muñoz

Accounting Technician Francisco Buenestado

Finance Assistant Anabel Alemany



FUNDING SERVICES

Funding Services Manager

Esther Gallardo



HUMAN RESOURCES

Head of Human Resources Carol Marí

HR Junior Technician Ricard Rius

Administrative Technician for Travel and Support Marta Redón

Occupational Hazards Prevention Technician Jordi Martínez



EVENTS

Events Manager Pilar Jiménez, Angels Lopez



COMMUNICATIONS

Communications Manager

Vienna Leigh



IT

IT Manager Juli Bafaluy

IT Technician Francisco Contreras

Statistics

Figure 1. IBEC researchers and technicians by group

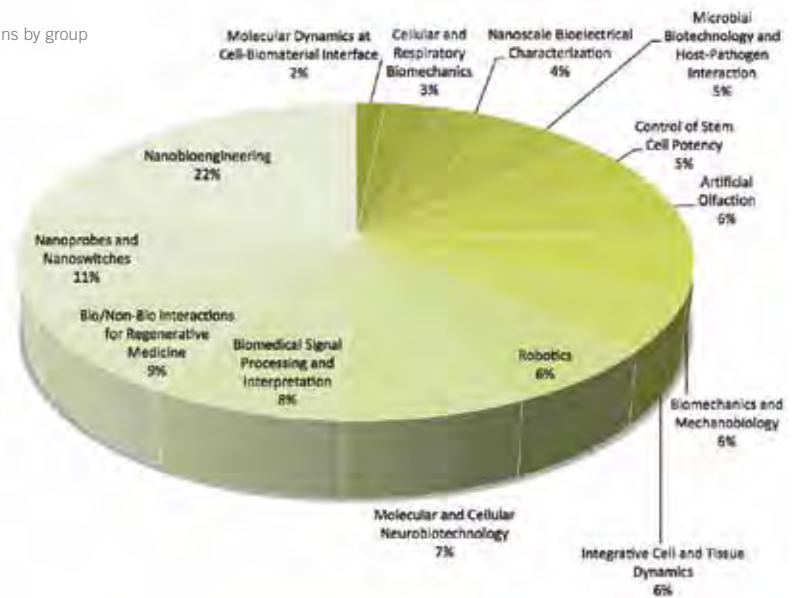
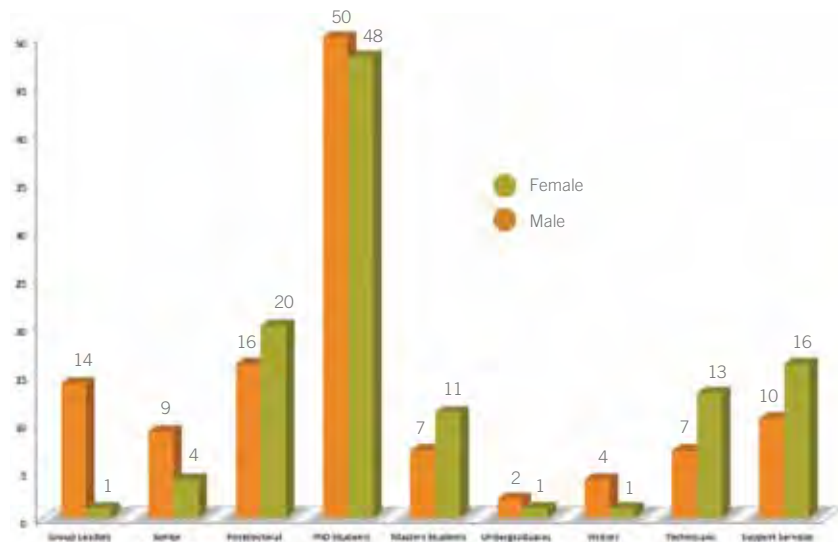


Figure 2. IBEC researchers, technicians and support services staff by gender and category



In 2011 IBEC's staff of researchers and expert technicians numbered 208. Some work on an in-house basis, some come from the University of Barcelona or the Technical University of Catalonia, and some are funded through programmes that support the recruitment of research staff such as the Bosch i Gimpera Foundation, ICREA and the Ramón y Cajal programme (MEC).

IBEC also employs a staff of 26 people to carry out support activities.

(All figures correct as of 31.12.11)

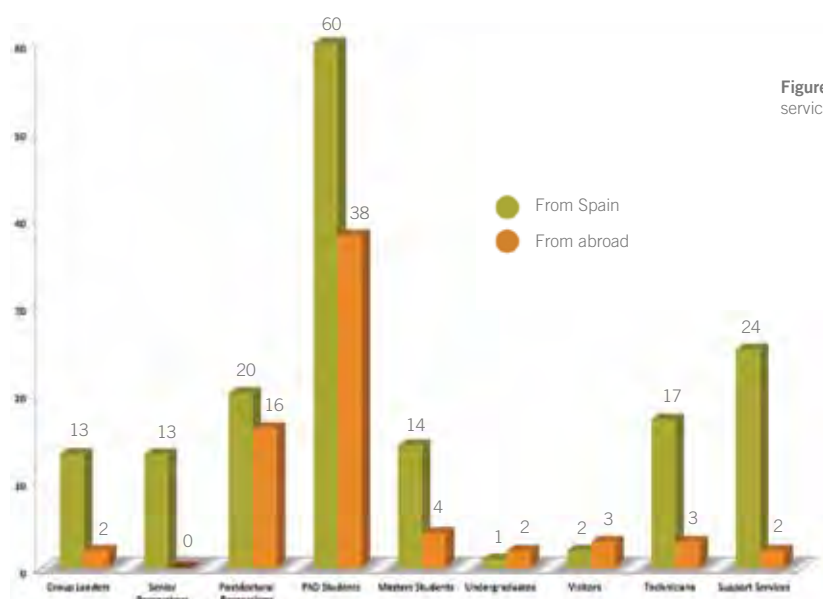


Figure 3. IBEC researchers, technicians and support services staff by nationality and category

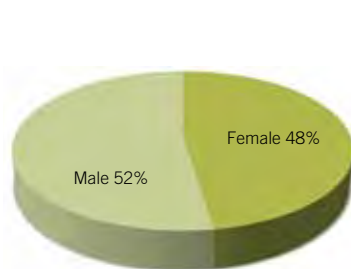


Figure 4. IBEC researchers and technicians by gender

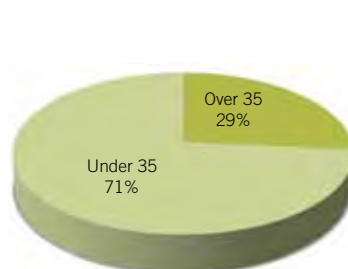


Figure 5. IBEC researchers and technicians by age

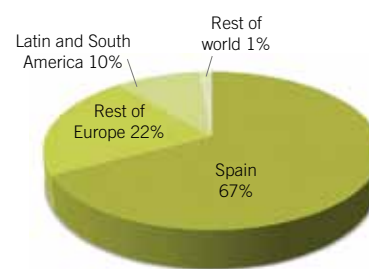


Figure 6. IBEC researchers and technicians by nationality

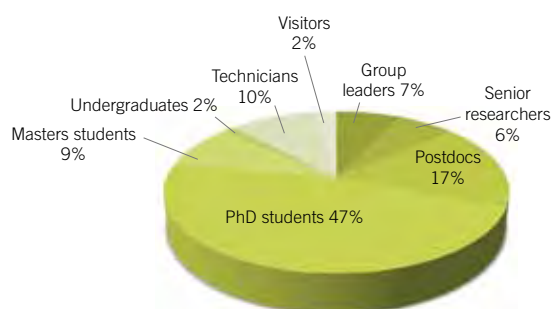


Figure 7. IBEC researchers and technicians by category

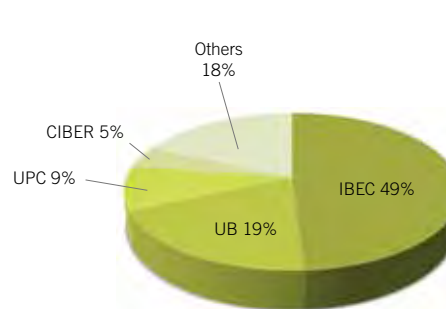


Figure 8. IBEC researchers and technicians by associated or contracting institution



IBEC's groups and their activities are organised into six research programmes: **Cellular Biotechnology, Biomechanics and cellular biophysics, Nanobiotechnology, Biomaterials, implants and tissue engineering, Medical signals and instrumentation, and Robotics and biomedical imaging.**



Research

KMnO₄ 0.06%

PBS

Microbial Biotechnology and
Host-Pathogen Interaction

Prof. Dr. Antonio Juárez



Molecular and Cellular
Neurobiotechnology

Prof. Dr. José Antonio Del Río



Control of Stem
Cell Potency

Prof. Dr. Ángel Raya



Cellular Biotechnology
programme

Microbial Biotechnology and Host-Pathogen Interaction

Group leader: Prof. Dr. Antonio Juárez

Senior researcher: Dr. Eduard Torrents

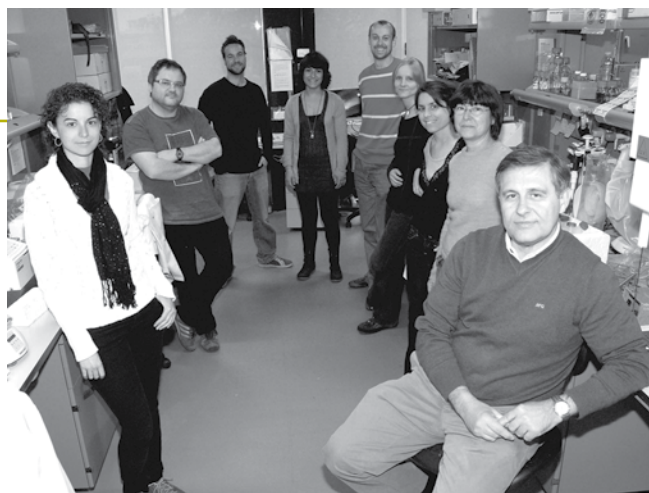
Postdoctoral researchers: Manuela Dietrich, Martin Edwards (shared with Gabriel Gomila, page 50)

PhD students: Daniel Esteban (shared with Gabriel Gomila, page 50), Nuria López, Maria del Mar Cendra, Laura Pedró, Francesca Staffieri

Masters students: Ingrid Nolla

Technicians: M^a Carmen Jaramillo

Visitors: Blanca Scarsciotti i Soler



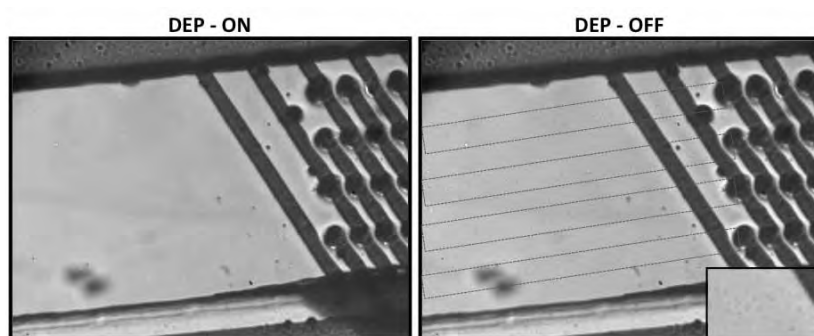
1. Structure and function of bacterial proteins that modulate virulence expression

Protein–protein and protein–DNA interactions play key roles in the ability of virulent bacteria to adapt to the host environment and cause disease. Two groups of proteins are currently the focus of our research: nucleoid-associated proteins (NAPs) that contribute to DNA architecture and modulate gene expression, and ribonucleotide reductases (RNRs), which are key enzymes in all living organisms providing the nucleotide precursors for DNA replication and repair. In the former group, we are interested in unravelling the role played by two of these proteins – Hha and H-NS – in the regulation of virulence and of plasmid transfer. In the case of the latter group, our current research objectives are to analyze the importance of bacterial RNRs in pathogenesis and the molecular mechanisms of gene expression and to identify new specific RNR inhibitors. Owing to their essential function, these enzymes offer excellent potential for combating bacterial infection.

2. Application of nanotools of bacterial biotechnology

2.1. Dielectrophoresis (DEP). We have previously shown that dielectrophoresis can be a valuable tool for bacterial cell sorting and characterization. We are currently using different chip designs (2D and 3D carbon electrodes) to: a) study the effect of electric fields on bacterial cell physiology; b) combine DEP with other molecular protocols for detection and identification of different types of cells.

2.2. Atomic force microscopy (AFM). Conventional AFM approaches have been shown to be powerful techniques for characterizing both biomaterials and biomolecules. In a joint project with the Nanoscale Bioelectrical Characterization group (page 50), we intend to use electrical-AFM to characterize the bacterial cell envelope. We also plan to use this approach to analyze the structural and physiological properties of bacterial living cells.



Trapping of *Escherichia coli* cells in a dielectrophoresis chip.

Research projects

■ **INTERMODS** Interconexiones de Módulos plasmídicos y los Genomas de Bacterias Patógenas (2008-2013).

PI: **Antonio Juárez** (managed by UB)

MICINN, Consejo Superior de Investigaciones Científicas (CSIC).

■ Proteínas restringidas a la familia *Enterobacteriaceae*: implicación en la transferencia génica horizontal y virulencia.

PI: **Antonio Juárez**

MICINN, BFU2010-21836-C02-01 (2011-2013).

■ Inhibición de la síntesis del AND bacteriano como Diana contra organismos patógenos en enfermos de fibrosis quística (2010-2013).

PI: **Eduard Torrents**

Beca de investigación Pablo Motos. Federación Española de Fibrosis Quística.

■ **PATHOGENOMICS** Identification of hot spots of divergence and rapidly changing genes within shiga toxin-producing *Escherichia coli* (2009-2012).

PI: **Eduard Torrents**

MICINN, Acciones Complementarias (ERANET).

■ Función de las ribonucleotidil reductasas bacterianas en patogenicidad: bases moleculares de la expresión génica y cribado de inhibidores específicos (2009-2011).

PI: **Eduard Torrents**

MICINN, Instituto de Salud Carlos III (FIS programme).

■ Grup de recerca consolidat (2009-2013).

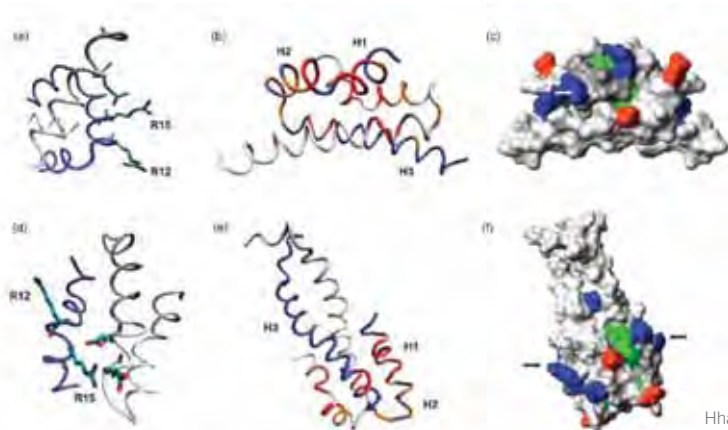
PI: **Antonio Juárez**

Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (SGR 2009).

■ Detecció de *Salmonella* (2010-2011).

PI: **Antonio Juárez**

Industrial project with Mevet.



Hha perturbing H-NS structure.

Publications

- Cordeiro, T. N., Schmidt, H., Madrid, C., Juarez, A., Bernado, P., Griesinger, C., Garcia, J. and Pons, M. (2011). Indirect DNA readout by an H-NS related protein: Structure of the DNA complex of the C-terminal domain of Ler. *Plos Pathogens*, 7 (11), 12
- Crona, M., Torrents, E., Rohr, A. K., Hofer, A., Furrer, E., Tomter, A. B., Andersson, K. K., Sahlin, M. and Sjöberg, B.-M. (2011). NrdH-redoxin protein mediates high enzyme activity in manganese-reconstituted ribonucleotide reductase from bacillus anthracis. *Journal of Biological Chemistry*, 286 (38), 33053-33060
- Pedro, L., Banos, R. C., Aznar, S., Madrid, C., Balsalobre, C. and Juarez, A. (2011). Antibiotics shaping bacterial genome: Deletion of an IS91 flanked virulence determinant upon exposure to subinhibitory antibiotic concentrations. *Plos One*, 6 (11), 11
- Sjöberg, B. M. and Torrents, E. (2011). Shift in ribonucleotide reductase gene expression in *pseudomonas aeruginosa* during infection. *Infection and Immunity*, 79 (7), 2663-2669
- de Alba, C. F., Solorzano, C., Paytubi, S., Madrid, C., Juarez, A., Garcia, J. and Pons, M. (2011). Essential residues in the H-NS binding site of Hha, a co-regulator of horizontally acquired genes in Enterobacteria. *Febs Letters*, 585 (12), 1765-1770
- Queiroz, M. H., Madrid, C., Paytubi, S., Balsalobre, C. and Juárez, A. (2011). Integration Host Factor alleviates H-NS silencing of the *Salmonella enterica* serovar Typhimurium master regulator of SPI1, hilA. *Microbiology-Sgm*, 157 (9), 2504-2514
- Banos, R. C., Aznar, S., Madrid, C. and Juarez, A. (2011). Differential functional properties of chromosomal- and plasmid-encoded H-NS proteins. *Research in Microbiology*, 162 (4), 382-385
- Banos, R. C., Martinez, J., Polo, C., Madrid, C., Prenafeta, A. and Juarez, A. (2011). The yfeR gene of *Salmonella enterica* serovar Typhimurium encodes an osmoregulated LysR-type transcriptional regulator. *Fems Microbiology Letters*, 315 (1), 63-71
- Rodríguez-Hernández, A., Juárez, A., Engel, E. and Gil, F. (2011). *Streptococcus sanguinis* adhesion on titanium rough surfaces: effect of shot-blasting particles. *Journal of Materials Science: Materials in Medicine*, 22 (8), 1-10

- Adrados, B., Julian, E., Codony, F., Torrents, E., Luquin, M. and Morato, J. (2011). Prevalence and concentration of non-tuberculous Mycobacteria in cooling towers by means of quantitative PCR: A prospective study. *Current Microbiology*, 62 (1), 313-319
- Paytubi, S., Garcia, J. and Juarez, A. (2011). Bacterial Hha-like proteins facilitate incorporation of horizontally transferred DNA. *Central European Journal of Biology*, 6 (6), 879-886

Collaborations with other research centres

- Prof. Britt-Marie Sjöberg** Molecular Biology and Functional Genomics Dept., Stockholm University (Sweden).
- Prof. Miquel Pons** Dept. de Química Orgànica, University of Barcelona (Spain).
- Dr. Esther Julián** Dept. de Genètica i de Microbiologia, Universitat Autònoma de Barcelona (Spain).
- Dr. Rodrigo Martínez-Duarte** École Polytechnique Fédérale de Lausanne (Switzerland).
- Prof. Mike Hughes** University of Surrey (UK).
- Prof. Josep Samitier** IBEC (page 42).
- Prof. Josep A. Planell** IBEC (page 53).
- Prof. Fernando Albericio** Institut de Recerca Biomèdica (IRB), (Spain).
- Dr. Gabriel Gomila** IBEC (page 50).
- Prof. F. García del Portillo** Centro Nacional de Biotecnología, Madrid (Spain).
- Prof. Josep Casadesús** Universidad de Sevilla (Spain).

Scientific equipment and techniques

- Microbial culture facilities
- Protein expression and purification systems
- Biomolecule production process
- Protein and DNA electrophoresis apparatus
- Thermocycler (PCR)

Molecular and Cellular Neurobiotechnology

Group leader: Prof. Dr. José Antonio del Río

Senior researcher: Dr. Rosalina Gavín

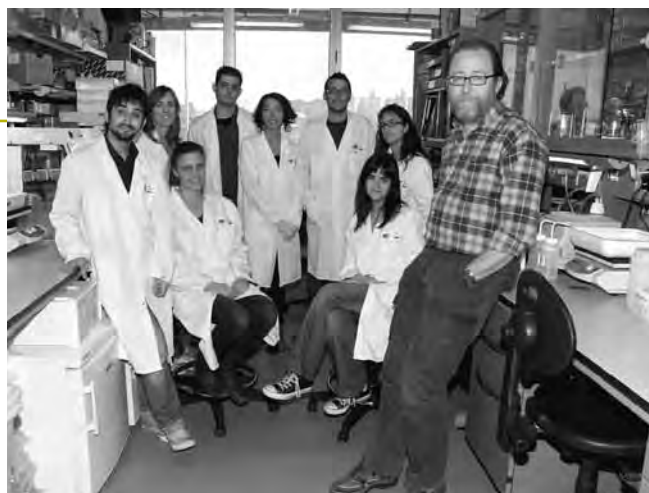
Postdoctoral researchers: Dr. Ana Bribián, Dr. Vanessa Gil, Dr. Franc Llorens, Dr. Sílvia Vilches

PhD students: Patricia Carulla, Sara Nocentini, Diego Reginensi, Óscar Seira, Cristina Vergara

Masters students: Jorge Gómez, Cristina León

Technician: Giovanna Tormen

Visitors: Cristina Riggio, Jordi Tomas Roig

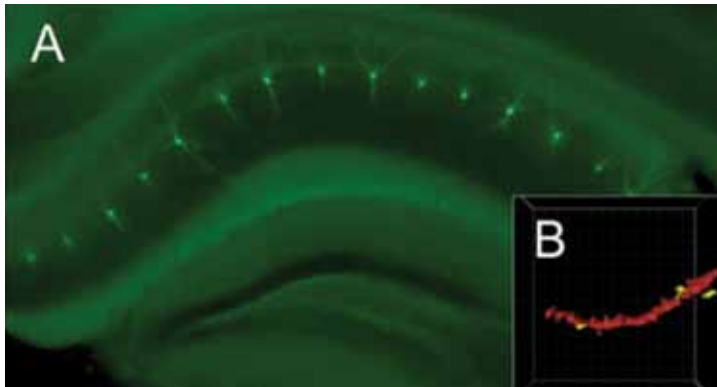


During 2011, the research group developed several studies aimed at understanding some of the processes of development and neurodegeneration of the central nervous system (CNS). Among these we demonstrated, in collaboration with other groups, the role of the cellular prion protein (PrP^c) in epilepsy. Our data indicate that PrP^c modulates glutamatergic neurotransmission by acting at the cell membrane together with the glutamate receptor subunits Glur6/7 and the postsynaptic density protein PSD-95. Thus the absence of PrP^c induces epilepsy by lacking the interaction with the glutamate receptor. In addition, we demonstrated that an intracellular kinase JNK3 is a target of PrP^c-mediated signaling. These data were included in a perspectives report in *Prion* (in press).

We also made progress in understanding the intracellular mechanisms responsible for the failure of axonal regeneration after CNS injury. In this area, we described the involvement of the intracellular kinase GSK3 β in the inhibitory effects of myelin-associated molecules. Current pharmacological studies using microfluidics are analyzing the putative effect of specific inhibitors of GSK3 β to increase axon regeneration.

From the technological point of view, the group published a methodological review in *Nature Protocols* (published in 2012) on the usefulness of three-dimensional culture with hydrogels in neurobiological studies. Moreover, in collaboration with other IBEC groups, we have characterized the role of myelin-associated proteins and their intracellular signaling cascades in the development of cell therapies using olfactory ensheathing cells, which are inhibited by myelin. In collaboration with Xavier Trepats group (page 39) we determined, for the first time, the behaviour of these cells using biomechanics and traction force analysis (*Cellular and Molecular Life Science*, in press). Current experiments in our groups are focused on avoiding this inhibition in order to increase the effectiveness of this cell type after spinal cord lesion.

Finally, group members have collaborated on the study of the analysis of the role of Epidermal Growth Factor roles on the normal development and disease, and how they affect cell proliferation and survival. To analyze this we have used a combined approach to study the EGF dependent transcriptome of HeLa cells by using multiple long oligonucleotide-based microarray platforms (from Agilent, Operon, and Illumina) in combination with digital gene expression profiling (DGE) with the Illumina Genome Analyzer.



A) Example of LEICA SP5 spinning disk confocal microscopy picture showing several CA1 pyramidal neurons of the hippocampus microinjected with fluorochromes. This observation is useful to analyze the dendritic morphology and its putative changes in mouse models of neurodegenerative diseases. B) Example of 3D reconstruction of a dendritic segment showing its spines using Silicon Graphics Imaris™ software.

Research projects

■ **PRIORITY** Protecting the Food Chain from Prions: Shaping European Priorities through Basic and Applied Research (2009-2013).

PI: **José Antonio Del Río** (managed by UB)
Integrated collaborative project within the framework of EU-FP7.

■ **DEVREG** Caracterización funcional de genes regulados durante la ontogenia del SNC en el desarrollo cortical y la regeneración axonal (2009-2012).

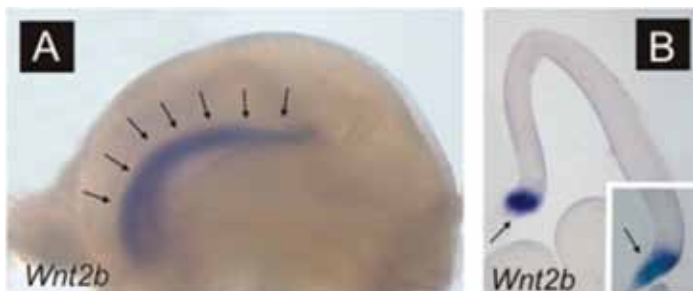
PI: **José Antonio Del Río**
MICINN, Investigación fundamental no orientada.

■ **DEMTEST** Biomarker based diagnosis of rapid progressive dementias – optimisation of diagnostic protocols.

PI: **José Antonio Del Río**
Instituto Carlos III, “Optimización de Biomarcadores y la Armonización de su uso” (2012-2014).

■ Grup de recerca consolidat (2009-2013).

PI: **José Antonio Del Río**
Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR), Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (SGR 2009).



A) Example of the detection of the Wnt2b mRNA by *in situ* hybridization in the cortical hem (arrows) of the developing mouse embryo. B) Example of Wnt2b mRNA detection arrows in the telencephalon of the mouse. Cells originated in the cortical hem are responsible of the correct laminar development of the cerebral cortex during ontogeny.

Publications

- Llorens, F., Gil, V. and Antonio del Rio, J. (2011). Emerging functions of myelin-associated proteins during development, neuronal plasticity, and neurodegeneration. *Faseb Journal*, 25 (2), 463-475
- Carulla, P., Bribian, A., Rangel, A., Gavin, R., Ferrer, I., Caelles, C., Antonio del Rio, J. and Llorens, F. (2011). Neuroprotective role of PrP(C) against kainate-induced epileptic seizures and cell death depends on the modulation of JNK3 activation by GluR6/7-PSD-95 binding. *Molecular Biology of the Cell*, 22 (17), 3041-3054
- Llorens, F., Hummel, M., Pastor, X., Ferrer, A., Pluvinet, R., Vivancos, A., Castillo, E., Iraola, S., Mosquera, A. M., Gonzalez, E., Lozano, J., Ingham, M., Dohm, J. C., Noguera, M., Kofler, R., Antonio del Rio, J., Bayes, M., Himmelbauer, H. and Sumoy, L. (2011). Multiple platform assessment of the EGF dependent transcriptome by microarray and deep tag sequencing analysis. *BMC Genomics*, 12, 326

Collaborations with other research centres

- Dr. Jung Keun Hyun** Dankook University, Yongin (Korea).
- Prof. Javier de Felipe** Instituto Cajal, Consejo Superior de Investigaciones Científicas (CSIC), Madrid (Spain).
- Dr. Fernando de Castro** Hospital Nacional de Paraplégicos, Toledo (Spain).
- Dr. Adolfo López de Munain** Hospital de Donostia, San Sebastian (Spain).
- Prof. Jose Manuel García Verdugo** Facultad de Ciencias, Universidad de Valencia (Spain).
- Prof. Josep A. Planell** IBEC (page 53)
- Prof. Josep Samitier** IBEC (page 42)

Prof. Xavier Trepát IBEC (page 39)

Prof. Angel Raya IBEC (page 29)

Prof. Jesús Ávila and Prof. Francisco Wandosell Consejo Superior de Investigaciones Científicas (CSIC), Universidad Autónoma de Madrid (Spain).

Prof. Isidro Ferrer Institut d'Investigació Biomèdica de Bellvitge. University of Barcelona (Spain).

Prof. Marc Tessier-Lavigne Genentech, Inc., South San Francisco (USA).

Prof. Fanny Man Developmental Institute of Marseille Luminy, Université de la Méditerranée, Marseille (France).

Prof. Yutaka Yoshida Division of Developmental Biology, Cincinnati Children's Research Foundation, Cincinnati, Ohio (USA).

Scientific equipment and techniques

- Neural stem cell culture
- Microscopy facility (Olympus BX61 and Olympus IX71 with LCI culture system)
- Electroporation system (BTX 600)
- Pressure microinjection system
- Protein expression and purification systems
- Technology of neuronal culture facilities (2D and 3D)
- Lentiviral production and characterization
- Gradient thermocycler (PCR)
- Protein and DNA electrophoresis
- *In situ* hybridization oven

Control of Stem Cell Potency

Group leader: Prof. Dr. Ángel Raya

Postdoctoral researcher: Dr. Sergio Mora, Dr. Adriana Rodríguez

Research assistants: Yvonne Richaud, Senda Jiménez, Cristina García

PhD students: Claudia Di Guglielmo, Isil Tekeli, Juan Luís Vázquez

Masters students: Bahaa Arefai

Undergraduates: Patrizia Benzoni, Marta Farrés, Andrea Blanco

Visiting students: Isaac Canals, Elisabetta Crescini, Martín Muñoz



During embryo development, the potency of the zygote is deployed through coordinated and stereotypical changes in cell behaviours and processes of tissue patterning, ultimately resulting in the formation of an entire, highly complex organism in a relatively short period of time. Throughout this process, the developmental potency of individual cells, i.e. their ability to give rise to cells of a different type than their own, is progressively lost, so that somatic cells in adult individuals retain very limited potency (such as in rare adult stem cells) or show no potency at all.

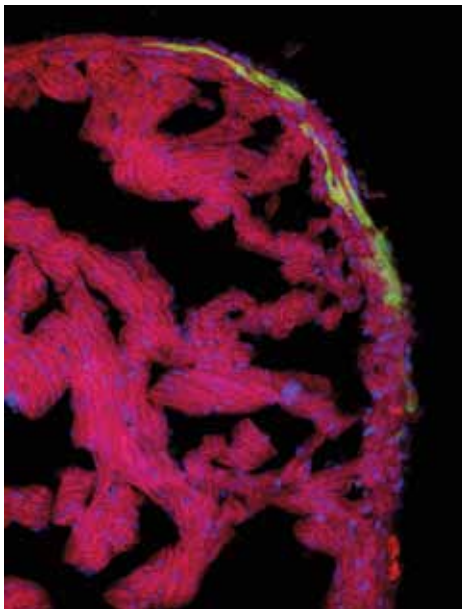
Our laboratory is interested in understanding the mechanisms that govern the degree of potency of human somatic cells, and how it can be experimentally increased for conditions where doing so may be of biomedical relevance. Specifically, the context in which we investigate these issues is mainly centred on the paradigm of cardiac regeneration/repair.

Heart-related diseases are the main cause of mortality in the world, with ischemic heart disease being the single most frequent condition accounting for the death toll. This results from the very limited ability of the mammalian heart to regenerate on its own, and underscores the pressing biomedical need to finding ways for potentiating this ability (heart regeneration) and/or providing new cardiac cells to replace the lost or damaged ones (heart repair). We pursue the first approach by studying the process of heart regeneration in the zebrafish, an organism with a remarkable regeneration capacity. Natural regeneration is a biologically fascinating phenomenon in which somatic cells may regain developmental potency, and we hope that understanding the molecular and cellular mechanisms that control this process will help devising strategies to potentiate the regeneration of adult mammalian hearts.

For achieving heart repair, in turn, our research is aimed at generating functional human heart muscle cells that could be used for transplantation. For this purpose, we investigate ways to manipulate the developmental potency of human somatic cells so they become pluripotent (i.e. regain the potency of cells in the early embryo), and then study how these so-called induced pluripotent stem cells (iPSC) can be instructed to differentiate into functional cardiomyocytes. In addition, since iPSC can



Colonies of human iPS cells showing high alkaline phosphatase activity (blue staining).



Section of a zebrafish heart showing a patch of genetically-labelled cells in green, and cardiomyocytes stained in red.

be generated from disease-carrying cells, many laboratories including ours are exploring the possibility of using patient-specific iPSC to generate disease-relevant cell types in which to investigate the pathogenic mechanisms of disease initiation and/or progression.

Overall, our research takes advantage of a variety of experimental paradigms (zebrafish heart regeneration, human iPSC generation and differentiation), approached from a multi-disciplinary perspective, ranging from bioengineering approaches to 3D stem cell differentiation to single-cell genetic lineage tracing analyses and genetic manipulation of human cells, aimed at tackling important current issues in biology and biomedicine, such as the mechanisms that control the establishment and maintenance of developmental potency, the initiation and progression of the regenerative process, and the differentiation and functional maturation of human cardiomyocytes, and the development of genuinely-human models of human disease.

Research projects

- Molecular and cellular bases of heart regeneration in the zebrafish.

PI: **Ángel Raya**

(BFU2006-12251/BMC).

- **RegenZebra** Molecular and cellular bases of heart regeneration in the zebrafish

PI: **Ángel Raya**

(MIRG-CT-2007-046523).

- Human pluripotent stem cells and zebrafish heart regeneration as experimental tools to understand cardiac muscle cell differentiation (2009-2012).

PI: **Ángel Raya**

MICINN, *Investigación fundamental no orientada*.

- **CELLSCAFF-CARTILAGE** *In situ* tissue engineering using stem cells and functional biomaterials to repair articular cartilage: An 'in vivo model' (2009-2012).

PI: **Ángel Raya**

MICINN, ACI-E Medicina Regenerativa (ACI-PLE2009-0144).

- Reparación de cartílago articular mediante ingeniería de tejidos *in situ*: modelo *in vivo* (iPSC).

PI: **Ángel Raya**

MICINN (ACI-2010-1117).

- Use of patient-specific induced pluripotent stem cells to improve diagnosis and treatment of Hemophilia A (2012-2014)

PI: **Ángel Raya**

ISCIII; E-Rare JTC 2011 (HEMO-iPS).

Publications

- Woods, N. B., Parker, A. S., Moraghebi, R., Lutz, M. K., Firth, A. L., Brennand, K. J., Berggren, W. T., Raya, A., Belmonte, J. C. I., Gage, F. H. and Verma, I. M. (2011). Brief report: Efficient generation of hematopoietic precursors and progenitors from human pluripotent stem cell lines. *Stem Cells*, 29 (7), 1158-1164

Collaborations with other research centres

Jordi Alberch/Josep M. Canals IDIBAPS, University of Barcelona (Spain).

Jordi Barquinero Institut de Recerca, Hospital Universitari Vall d'Hebron, Barcelona (Spain).

Antoni Bayés-Genís Hospital Universitari Germans Trias i Pujol, Barcelona (Spain).

Francisco J. Blanco Complejo Hospitalario Universitario, A Coruña (Spain).

Jerónimo Blanco/Núria Rubio Cardiovascular Research Center CSIC-ICCC, Barcelona (Spain).

Juan Bueren CIEMAT, Madrid (Spain).

Antonella Consiglio IBUB, University of Barcelona (Spain).

Patrizia Dell'Era Università degli Studi di Brescia (Italy).

Sheng Ding Scripps Research Institute, La Jolla (USA).

Antonia Follenzi Università del Piemonte Orientale, Novara (Italy).

Manuel Galiñanes Hospital Universitari Vall d'Hebron, Barcelona (Spain).

Rafael Garesse Instituto de Investigaciones Biomédicas "Alberto Sols"/UAM (Spain).

Daniel Grinberg/Lluïsa Vilageliu University of Barcelona (Spain).

José López Barneo IBiS, Sevilla (Spain).

Pedro Muniesa Facultad de Veterinaria, Zaragoza (Spain).

Eduard Tolosa Hospital Clínic, Barcelona (Spain).

Miquel Vila Institut de Recerca, Hospital Universitari Vall d'Hebron, Barcelona (Spain).

Anne Weber/Anne Dubart Inserm, Le Kremlin-Bicêtre Cedex (France).

Scientific equipment and techniques

- hES/iPS cell culture station
- Zebrafish transgenesis
- Molecular biology facilities
- Stereomicroscope for picking hES colonies
- Cell culture facilities



Cellular and Respiratory Biomechanics

Prof. Dr. Daniel Navajas



Nanoprobes and nanoswitches

Prof. Dr. Pau Gorostiza and
Prof. Dr. Fausto Sanz



Integrative Cell and Tissue Dynamics

Prof. Dr. Xavier Trepap

Biomechanics and Cellular Biophysics programme



Cellular and Respiratory Biomechanics

Group leader: Prof. Dr. Daniel Navajas

Senior researchers: Dr. Pere Roca-Cusachs

PhD students: Tomàs Luque González

Masters student: Anita Joanna Kosmalska,
Laura Schaedel



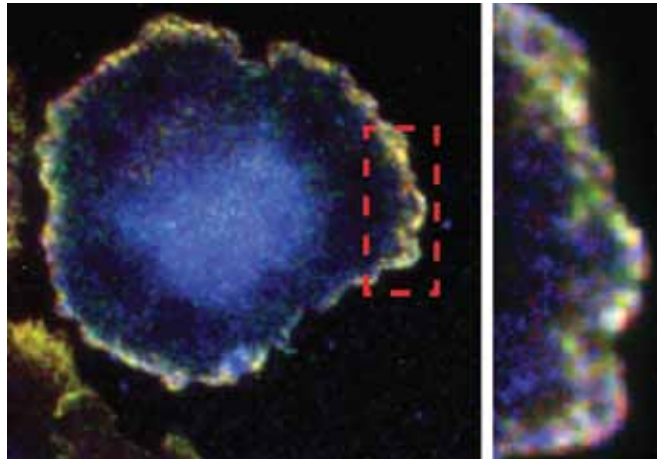
Our goal is to gain a better understanding of cellular and respiratory biomechanics in order to improve the diagnosis and treatment of respiratory disease. Our work is organized into two interrelated areas, focusing on respiratory mechanics at both the systemic and the cellular level. We use basic and translational approaches in a multidisciplinary framework involving cooperation with clinical research groups working in the field of respiratory medicine.

At the systemic level, we study the mechanical properties of the airway and lung tissues and the changes that occur in the context of the mechanical dysfunction associated with respiratory diseases. We study the mechanics of the upper airway in sleep apnea syndrome and on mechanical ventilation in acute and chronic respiratory failure. We biofabricate engineered lungs by recellularizing lung scaffolds with stem cells.

At the cellular level, we develop and apply cutting-edge nanotechnology and advanced biophysical techniques to probe the mechanical behaviour of cells and their mechanical interactions with their microenvironment. We study the mechanical properties of the cell and its response to inflammation and mechanical stresses and develop new approaches to differentiate stem cells using mechanical stimuli. We are developing a lung-on-a-chip model recreating the *in vivo* mechanical micro/nano-environment of lung cells. Magnetic tweezers and atomic force microscopy are also combined with molecular biology and advanced optical microscopy with the aim of understanding how cells detect and respond to mechanical stimuli. Using this approach we have, for instance, revealed that different integrins are adapted to sensing versus resisting forces or that talin molecules can detect forces by stretching and exposing cryptic binding sites to vinculin. Ultimately, when we determine the molecular mechanisms that communicate cells with their environment, we will understand how forces determine development when things go right and tumour formation when they go wrong.



Decellularized rat lung.

Spreading fibroblast showing initial adhesions to the extracellular matrix containing α -actinin (green) talin (red) and β 3 integrin (blue).

Research projects

■ **CELL TRANS** Integrated Molecular and Cellular Mechanotransduction Mediated by Protein (2008-2011).
Fellow: **Pere Roca-Cusachs**

PI: **Daniel Navajas**

International Outgoing Fellowships (IOF) Marie Curie Action within the framework of EU-FP7.

■ Alteración de la Nanomecánica de los neutrófilos en la lesión pulmonar inducida por el ventilador.

PI: **Daniel Navajas** (managed by UB)

Fondo de Investigación Sanitaria. Ministerio de Sanidad y Consumo (PI081908).

■ Fisiopatologia i Tractament de les Malalties Respiratòries (2009-SGR-911).

PI: **A. Torres** (managed by Fundació Clínic)

Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (2009-2013).

■ **NANONET** Nanomechanics of intermediate filament networks.

Chair: **E. Hol**

Management Committee Member: **Daniel Navajas**

European Commission COST Action (BMBS-BM1002).

■ **AFM4NanoMed&Bio** European network on applications of Atomic Force Microscopy to NanoMedicine and Life Sciences.

Chair: **P. Parrot**

Management Committee Member: **Daniel Navajas**

European Commission COST Action (BMBS-TD1002).

■ Mechanical signaling driving stem cell differentiation in the lung. Lung-on-a-chip model.

PI: **Daniel Navajas**

Fondo de Investigación Sanitaria, Ministerio de Ciencia e Innovación. (PI11/00089).

■ Identifying molecular mechanical pathways in cells (2012-2015).

PI: **Pere Roca-Cusachs**

Proyectos de investigación fundamental no orientada, Ministerio de economía y competitividad (BFU2011-23111).

■ Mechanical pathways in cells: from molecular mechanisms to cell function (2012-2015).

PI: **Pere Roca-Cusachs**

Coordinator: **Daniel Navajas**

Career Integration Grants (CIG) Marie Curie Action within the framework of EU-FP7 (MecPath 303848).

Publications

- Gauthier, N. C., Fardin, M. A., Roca-Cusachs, P. and Sheetz, M. P. (2011). Temporary increase in plasma membrane tension coordinates the activation of exocytosis and contraction during cell spreading. *Proceedings of the National Academy of Sciences of the United States of America*, 108 (35), 14467-14472
- Almendros, I., Farre, R., Planas, A. M., Torres, M., Bonsignore, M. R., Navajas, D. and Montserrat, J. M. (2011). Tissue oxygenation in brain, muscle, and fat in a rat model of sleep apnea: Differential effect of obstructive apneas and intermittent hypoxia. *Sleep*, 34 (8), 1127-1133
- Dellaca, R., Montserrat, J. M., Govoni, L., Pedotti, A., Navajas, D. and Farre, R. (2011). Telemetric CPAP titration at home in patients with sleep apnea-hypopnea syndrome. *Sleep Medicine*, 12 (2), 153-157
- Cagido, V. R., Zin, W. A., Ramirez, J., Navajas, D. and Farre, R. (2011). Alternating ventilation in a rat model of increased abdominal pressure. *Respiratory Physiology & Neurobiology*, 175 (3), 310-315
- Carreras, A., Wang, Y., Gozal, D., Montserrat, J. M., Navajas, D. and Farre, R. (2011). Non-invasive system for applying airway obstructions to model obstructive sleep apnea in mice. *Respiratory Physiology & Neurobiology*, 175 (1), 164-168
- Mathur, A., Roca-Cusachs, P., Rossier, O.M., Wind, S.J., Sheetz, M.P. and Hone, J. (2011). New approach for measuring protrusive forces in cells. *Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures* 29: 06FA02

Collaborations with other research centres

Prof. Ramon Farré Unit of Biophysics and Bioengineering, Dept. Physiological Sciences, School of Medicine, University of Barcelona/IDIBAPS, Barcelona (Spain).

Prof. J. M. Montserrat Service of Pneumology, Hospital Clinic/IDIBAPS, Barcelona (Spain).

Prof. M. Sheetz Biological Sciences, Columbia University New York (USA).

Prof. A. Pedotti Bioengineering Dept., Politecnico di Milano (Italy).

Prof. J. Cortiella Laboratory of Tissue Engineering and Regenerative Medicine, University of Texas Medical Branch, Galveston (USA).

Prof. A. Artigas Intensive Care Service, Hospital Sabadell (Spain).

Prof. James Hone Mechanical Engineering, Columbia University (USA).

Prof. Miguel Ángel del Pozo Centro Nacional de Investigaciones Cardiovasculares (CNIC), Madrid (Spain).

Scientific equipment and techniques

- Fluorescence resonance energy transfer (FRET) microscopy
- Confocal Microcopy
- Traction Microscopy
- Live cell fluorescence microscopy
- Cell stretching
- Cell culture
- Magnetic Tweezers
- Atomic Force Microscopy
- Surface Micro/Nano-patterning
- Optical Tweezers

Nanoprobes and nanoswitches

Group leaders: Prof. Dr. Pau Gorostiza and Prof. Dr. Fausto Sanz

Postdoctoral researcher: Dr. M^a Isabel Bahamonde, Dr. Felipe Caballero Briones, Dr. Ismael Díez Pérez, Dr. Kay Eckelt, Dr. Olga Esteban, Dr. Marina Inés Giannotti, Dr. Ana Traperó

PhD students: Juan Manuel Artés, Antonio Bautista, Xavier Gómez, Javier Hoyo, Mercè Izquierdo, Helena Masanas, Andrés Martín, Anna Palacios, Silvia Pittolo Lorena Redondo

Masters student: Míriam Ferrer, Montserrat López, Josep Relat

Undergraduates: Arnaud Giraudet, Lia Lima, Cristina Rivero

Technicians: Dr. Núria Camarero, Èric Ferrer, Ariadna Pérez

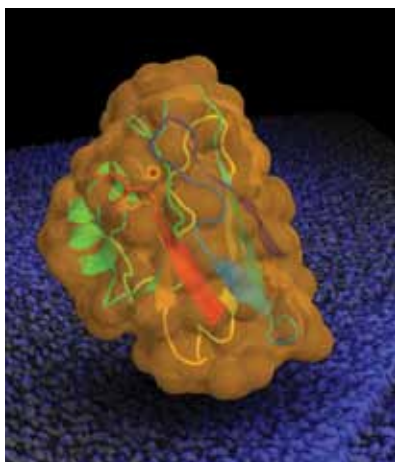
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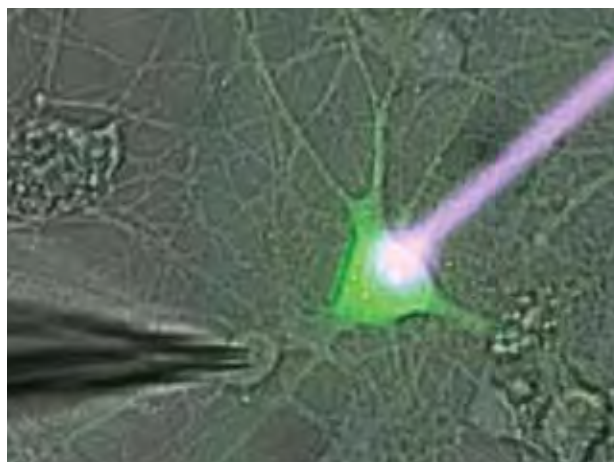
The group's research focuses on developing nanoscale tools to study biological systems. These tools include instrumentation based on proximity probes, such as electrochemical tunnelling microscopy and spectroscopy, that we apply to investigate electron transfer in metal oxides and individual redox proteins.

These studies are relevant to the development of biosensors and molecular electronics devices. In particular, we have recently published a method to measure directly the distance decay constant that characterizes the rate of electron transfer (ET) in redox proteins, and we have reported single protein junctions consisting of azurin bridged between a gold substrate and the probe of an electrochemical tunneling microscope, which constitute a proof-of-principle of a single redox protein field-effect transistor. Another set of nanotools that we are developing is based on molecular actuators that can be switched with light, such as azobenzene, which can be chemically attached to biomolecules in order to optically control their activity.

We are specifically interested in the processes of neurotransmitter secretion by exocytosis and membrane recycling by endocytosis, which are the fundamental phenomena that occur at the synaptic terminal and that participate in the communication between neurons. We have recently set up a method to control neurotransmitter exocytosis with light at the presynaptic compartment by activating a calcium-permeable, light-gated glutamate receptor (LiGluR) in cultured cells. Presynaptic expression of LiGluR in hippocampal neurons enables direct and reversible control of neurotransmission with light, and has allowed for the first time to modulate the firing rate of the postsynaptic neuron with the wavelength of illumination.



Crystal structure of redox protein azurin (Protein Data Bank entry: 1AZU) displaying its solvent accessible surface (gold) superimposed on the tertiary structure (rainbow) and a red sphere indicating the copper ion. When an atomically flat gold electrode is coated with azurin, the protein can be imaged under potentiostatic control by electrochemical tunneling microscopy (3D rendering of a 100x100nm² area shown in blue), and its electron transfer properties can be investigated by current-distance spectroscopy (Juan Manuel Artés *et al.*, *ACS Nano* 2011).



Representation of the invasive manipulation of neuronal activity by means of a conventional glass electrode in contact with the neuron on the left, and noninvasively by means of a focalized light beam over the green neuron on the right (Photomontage: Mercè Izquierdo).

Research projects

■ **OPTICALBULLET** Neurosecretion by Remote Control of Exocytosis and Endocytosis with Light (2008-2013).
PI: **Pau Gorostiza** (coordinator)
ERC Starting Independent Researcher Grant (ERC-StG) within the framework of EU-FP7.

■ **Photosyn-STM** Single-Molecule Studies of Photoconductance on Photosynthetic Molecular Systems by SPM Break-Junction Measurements (2008-2011).
PI: **Fausto Sanz** Fellow: **Ismael Díez**
International Outgoing Fellowships (IOF) Marie Curie Action within the framework of EU-FP7.

■ **PASVD** Photo-activated SVD (2010-2012).
PI: **Pau Gorostiza** Fellow: **M^a Isabel Bahamonde**
International Incoming Fellowships (IIF) Marie Curie Action within the framework of EU-FP7.

■ **OPTICAL SWITCH** Development of Photoswitchable Molecules with Biological Applications (2008-2011).
PI: **Pau Gorostiza**
MICINN, Investigación fundamental no orientada.

■ **Bioelectrochemistry and Nanotechnologies** (2009-SGR-277).

PI: **Fausto Sanz**
Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (2009-2013).

■ **Development of light-modulated allosteric ligands for remote, non-invasive regulation of neuropathic pain** (2010-2012).

PI: **Pau Gorostiza**
RecercaCaixa, Obra Social "la Caixa".

■ **FOCUS** Single Molecule Activation and Computing (2011-2013).

PI: **Pau Gorostiza** (Coordinator: Vincent Torre)
European Commission Future and Emerging Technologies proactive 7: Molecular Scale Devices and Systems FP7-ICT-2009 8.7 (270483).

Publications

- Artés, J. M., Díez-Pérez, I., Sanz, F. and Gorostiza, P. (2011). Direct measurement of electron transfer distance decay constants of single redox proteins by electrochemical tunneling spectroscopy. *ACS Nano*, 5 (3), 2060-2066
- Caballero-Briones, F., Palacios-Adrós, A. and Sanz, F. (2011). CuInSe₂ films prepared by three step pulsed electrodeposition. Deposition mechanisms, optical and photoelectrochemical studies. *Electrochimica Acta*, 56 (26), 9556-9567
- Díez-Pérez, I., Hihath, J., Hines, T., Wang, Z.-S., Zhou, G., Mullen, K. and Tao, N. (2011). Controlling single-molecule conductance through lateral coupling of [pi] orbitals. *Nature Nanotechnology*, 6 (4), 226-231
- Giannotti, M. I., Esteban, O., Oliva, M., Garcia-Parajo, M. F. and Sanz, F. (2011). pH-Responsive polysaccharide-based polyelectrolyte complexes as nanocarriers for lysosomal delivery of therapeutic proteins. *Biomacromolecules*, 12 (7), 2524-2533
- Roa, J. J., Oncins, G., Diaz, J., Capdevila, X. G., Sanz, F. and Segarra, M. (2011). Study of the friction, adhesion and mechanical properties of single crystals, ceramics and ceramic coatings by AFM. *Journal of the European Ceramic Society*, 31 (4): 429-449
- Roa, J. J., Oncins, G., Diaz, J., Sanz, F. and Segarra, M. (2011). Calculation of young's modulus value by means of AFM. *Recent Patents on Nanotechnology*, 5 (1), 27-36
- Simao, C., Mas-Torrent, M., Crivillers, N., Lloveras, V., Artés, J. M., Gorostiza, P., Veciana, J. and Rovira, C. (2011). A robust molecular platform for non-volatile memory devices with optical and magnetic responses. *Nature Chemistry*, 3 (5), 359-364
- Díez-Pérez, I., Hihath, J., Li, Z., Hines, T. and Tao, N. (2011). Last advances in single-molecule electric contacts. *241st National Meeting and Exposition of the American Chemical Society (ACS)*, Anaheim, USA
- Gorostiza, P. and Isacoff, E. Y. (2011). Photoswitchable ligand-gated ion channels. In: *Photosensitive molecules for controlling biological function* (ed. Chambers, J. J. and Kramer, R. H.) 55, 267-285, Springer, Saskatoon, Canada

Collaborations with other research centres

- Prof. Amadeu Llebaria** Institut de Química Avançada de Catalunya (IQAC-CSIC), Barcelona (Spain).
- Prof. Ernest Giralt** Dept. de Química Orgànica, UB (Spain).
- Prof. Miquel Àngel Pericàs** Institut Català d'Investigació Química (ICIQ), Tarragona (Spain).
- Dr. Piotr Bregestovski** Institut de Neurobiologie de la Méditerranée (INMED), Marseille (France).
- Dr. Mireia Oliva** Dept. de Farmàcia i Tecnologia Farmacèutica, UB (Spain).
- Dr. Artur Llobet** Dept. Patologia y Terapéutica Experimental, Universitat de Barcelona (Spain).
- Dr. Joan Torrent** Escola Universitària d'Òptica i Optometria de Terrassa (Spain).
- Prof. Dirk Trauner** Chemistry Dept., UC Berkeley (USA).
- Dr. Carles Solsona** Pathology and Experimental Therapeutics Dept, Universitat de Barcelona (Spain).
- Prof. Francisco Ciruela** ICREA and Universitat de Barcelona (Spain).
- Prof. Jesús Giraldo** Universitat Autònoma de Barcelona (Spain).

Scientific equipment and techniques

- iMic molecular imaging system
- Electrochemical scanning tunnelling microscope (STM) for molecular imaging
- Asylum Research Molecular Force Probe
- Multimode SPM Nanoscope III (SCT-UB)
- Autolab potentiostat
- Patch clamp setup with Heka EPC10 amplifier.
- Molecular Imaging Electrochemical STM.

Integrative Cell and Tissue Dynamics

Group leader: Prof. Dr. Xavier Trepap

Postdoctoral researcher: Dr. Elsa Bazellères, Dr. Vito Conte, Dr. Romaric Vincent

PhD students: Ester Añón, Agustí Brugués, Laura Casares, Simón García, Xavier Serra

Masters students: Sònia Pintor

Technician: Maria Angeles Bintanel



Cell motility and tissue dynamics

The ability of eukaryotic cells to migrate within living organisms underlies a wide range of phenomena in health and disease. When properly regulated, cell migration enables morphogenesis, host defense and tissue healing. When regulation fails, however, cell migration mediates devastating pathologies such as cancer, vascular disease and chronic inflammation. Our research focuses on understanding the fundamental biophysical mechanisms underlying migration both at the single cell level and at the tissue level.

Cytoskeletal fragility

With every beat of the heart, inflation of the lung or peristalsis of the gut, cell types of diverse function are subjected to substantial mechanical forces. How cells sense and respond to such forces underlies fundamental biological functions including differentiation, proliferation, polarization, locomotion, invasion, gene expression and pattern formation. We recently identified a new class of universal cellular responses to mechanical forces we termed “cytoskeletal fluidization” (Trepap *et al* (2007), *Nature*). The existence of this response class implies that the cytoskeleton of the living cell should no longer be regarded as a robust and stable scaffold but as a fragile one that is able to fluidize and quickly reorganize to adapt to its active mechanical environment. Our current research focuses on better understanding the functional implications of cytoskeletal fluidization and elucidating the underlying physical mechanisms.

Research projects

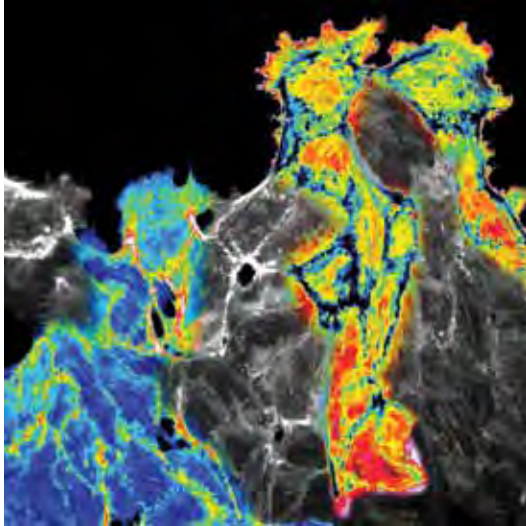
■ Physical Forces Driving Collective Cell Migration: From Genes to Mechanism (2009-2014).

PI: **Xavier Trepap**

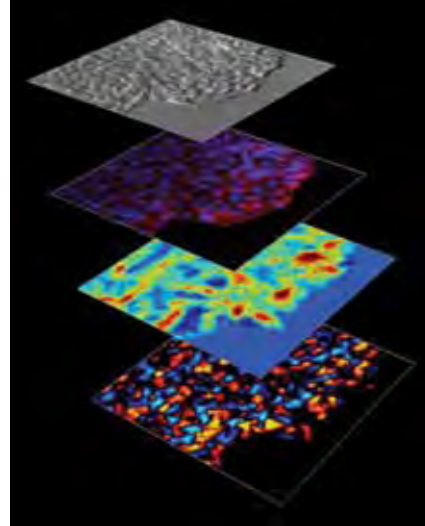
European Research Council IDEAS Starting Grants.

■ Study of the Physical Forces Driving Collective Cell Migration During Lung Epithelial Repair (2009-2012).
PI: **Xavier Trepap** (managed by UB)
MICINN.

■ Mechanics of Monolayer Migration (2011-2016).
Co-Investigator: **Xavier Trepap** (PI: Jeffrey Fredberg)
National Institutes of Health (USA).



Cells migrating within a sheet exhibit large dynamic heterogeneities.



Our lab has developed techniques to simultaneously map cell velocities, cytoskeletal structure, intercellular stresses, and cell-substrate tractions (from top to bottom).

Publications

- Tambe, D. T., Corey Hardin, C., Angelini, T. E., Rajendran, K., Park, C. Y., Serra-Picamal, X., Zhou, E. H., Zaman, M. H., Butler, J. P., Weitz, D. A., Fredberg, J. J. and Trepap, X. (2011). Collective cell guidance by cooperative intercellular forces. *Nature Materials*, 10 (6), 469-475
- Trepap, X. and Fredberg, J. J. (2011). Plithotaxis and emergent dynamics in collective cellular migration. *Trends in Cell Biology*, 21 (11), 638-646
- Angelini, T. E., Hannezo, E., Trepap, X., Marquez, M., Fredberg, J. J. and Weitz, D. A. (2011). Glass-like dynamics of collective cell migration. *Proceedings of the National Academy of Sciences*, 108 (12), 4714-4719
- Krishnan, R., Klumpers, D. D., Park, C. Y., Rajendran, K., Trepap, X., van Bezu, J., van Hinsbergh, V. W. M., Carman, C. V., Brain, J. D., Fredberg, J. J., Butler, J. P. and van Nieuw Amerongen, G. P. (2011). Substrate stiffening promotes endothelial monolayer disruption through enhanced physical forces. *American Journal of Physiology - Cell Physiology*, 300 (1), C146-C154
- Trepap, X. (2011). Forcing tumor arrest. *Physics*, 4, 85

Collaborations with other research centres

Erik Sahai Cancer Research (UK).

Roberto Mayor University College London (UK).

Benoit Ladoux Université Paris 7 (France).

Jim Butler Harvard University, Boston (USA).

Jeff Fredberg Harvard University, Boston (USA).

Roger Guimerà Univeritat Rovira i Virgili, Tarragona (Spain).

Eduard Batlle Institute for Research in Biomedicine, Barcelona (Spain).

Julien Colombelli Institute for Research in Biomedicine, Barcelona (Spain).

Joaquim Gea Hospital del Mar, Barcelona (Spain).

Scientific equipment and techniques

- Soft Lithography
- Micro/Nano fabrication
- Cell stretching
- Live Confocal Microscopy
- Magnetic Tweezers
- Magnetic Twisting Cytometry
- Monolayer stress microscopy
- Traction microscopy



Nanobioengineering

Prof. Dr. Josep Samitier



Single Molecule Bionanophotonics (until July 2011)

Prof. Dr. María García-Parajo



Nanoscale Bioelectrical Characterization

Dr. Gabriel Gomila

Nanobiotechnology
programme

Nanobioengineering

Group leader: Prof. Dr. Josep Samitier

Senior researchers: Dr. Xavier Fernández Busquets, Dr. Elena Martínez, Dr. Christian Sporer

Postdoctoral researchers: Dr. Mònica Mir, Dr. Antoni Homs, Dr. Patrizia Iavicoli, Dr. Beatriz Prieto, Dr. Anna Lagunas, Dr. Juan José Valle

PhD students: Juan Pablo Aguil, Juan Manuel Álvarez, Hugo Caffaratti, Cristina Casas, Oscar Castillo, Jordi Comelles, Maruxa Estévez, M^a Teresa Galán, Verónica Hortigüela, Joana Marques, Sergio Martínez, Ernest Moles, Beatriz Del Moral, Sabine Oberhansl, Ana M^a Oliva, Wilmer Alfonso Pardo, César Alejandro Parra, Ivón Rodríguez, Marta Sanmartí, Marília Barreiros dos Santos, José Luis Sebastián, Islam Bogachan Tahirbegi, Patricia Urbán, Rosa Letizia Zaffino

Technicians: Miriam Funes, David Izquierdo, Dr. Reyes Malavé, Èlia Solà, Javier Soraluce

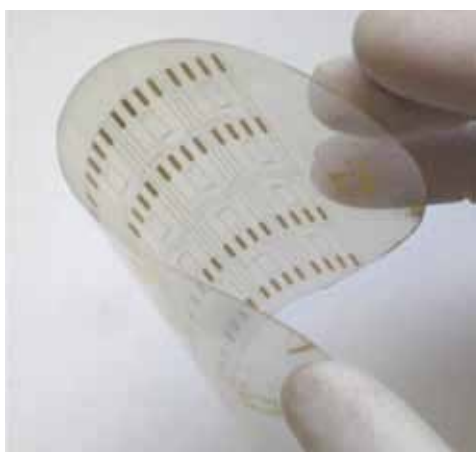


The Nanobioengineering group is a truly multidisciplinary team composed by researchers coming from very diverse backgrounds (chemistry, physics, material science, electronic engineering, pharmacy and molecular biology) and working together in applying nanotechnology to the development of new biomedical systems and devices, mainly for diagnostic purposes. The main activities of the group involve the physical and chemical functionalization of materials for the study of biomolecule and cell interactions and for the development of new biosensors that will be integrated in lab-on-a-chip devices. The technology and results obtained in the laboratory are employed in medical applications ranging from portable diagnosis devices to implantable prostheses for regenerative medicine purposes.

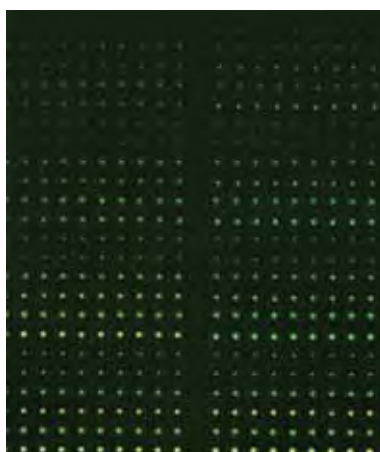
The projects carried out by the group are focused on clinical and industrial problems and are related to four convergent research lines:

1. Optical and electrochemical biosensors for clinical diagnosis and food safety applications

- DNA sensors for detection of cancer biomarkers
- Antibody-based sensors for detection of pathogenic microorganisms
- Aptamer-based sensors for detection of toxins
- Olfactory receptor-based sensors for detection of odorants and volatile compounds
- Polymer nanowires-based biosensors



Gold electrodes on PEN with a minimum feature size of 6 ± 1 μ m over a maximum substrate size of 10 cm in diameter. © DVT-IMP project.



Representative fluorescence scanner image of an a-PMMA protein microarray.

2. Bio/non-bio interfaces and micro/nano-environments for biomedical studies and regenerative medicine applications

- Design, production and characterization of micro/nanoenvironments with different biocompatible materials for cell behaviour studies (adhesion, proliferation, differentiation)
- Design, production and characterization of scaffolds with a topography and chemical composition controlled at the nanoscale for ocular and cardiac tissue regenerative therapies based on stem cells

3. Microfluidic systems for biological studies and lab-on-a-chip devices

- Microfluidic chip for blood/plasma filtering
- Microfluidic chip using hydrodynamic focusing for bacteria counting and sorting
- Microfluidic chip for reagent handling in POC diagnosis devices

4. Nanotechnology applied to biomolecule interaction studies

- Liposome-based nanovectors and nanoparticles for drug delivery
- Magnetic nanoparticles–biomolecules interactions and their applications

Research projects

■ **BOND** Bioelectronic Olfactory Neuron Device (2009-2013).

Coordinator: **Josep Samitier** (for the UB)

Technical Manager: **Gabriel Gomila** (see page 50)

Collaborative project (NMP) within the framework of EU-FP7.

■ **ARAKNES** Array of Robots Augmenting the KiNematics of Endoluminal Surgery (2008-2012).

PI: **Josep Samitier** (managed by UB)

Collaborative project (ICT) within the framework of EU-FP7.

■ **THERAEDGE** An Integrated Platform Enabling Therapeutic Applications at the Point of Primary Care (2008-2011).

PI: **Josep Samitier** (managed by UB)

Collaborative project (ICT) within the framework of EU-FP7.

■ **ONCONANOTARGET** Advancing the Field of Drug Delivery - Combined Targeted Treatment against Human Breast Cancer and Human Leukemia (2009-2011).

PI: **Josep Samitier**

MICINN, I+D+i Euroinvestigación.

■ **NANOMEDIAG** Nanobioanalytical Platforms for Improved Medical Diagnosis of Infections Caused by Pathogen Microorganisms (2009-2011).

IP: **Elena Martínez**

MICINN, I+D+i Euroinvestigación.

■ **CARDIO-STEM** Terapias regenerativas con células madre para el fallo cardíaco (2009-2012).

PI: **Josep Samitier**

MICINN, ACI-E Medicina Regenerativa.

■ **NANOMALARIA** Desarrollo de nanovectores para la liberación dirigida de antimaláricos (2009-2011).

IP: **Xavier Fernández-Busquets**

MICINN, Investigación fundamental no orientada.

■ **MINAHE3** Bio-Functionalization of Micronanotools to Study, Tag and Actuate Inside Living Cells (2009-2011).

PI: **Christian Sporer** (managed by UB)

MICINN, Investigación fundamental no orientada.

■ **NANOBIOMED** Nanotecnologías en biomedicina (2006-2010).

PI: **Xavier Fernández-Busquets** (managed by PCB)

MICINN, Actividad Investigadora CONSOLIDER.

■ Diagnóstico y pronóstico de cáncer de próstata mediante nanobiosensores híbridos multianálito (2011-2013).

PI: **Josep Samitier** (coordinator), **Elena Martínez**

MICINN, Instituto de Salud Carlos III. Subprograma de Proyectos de investigación en salud (FIS).

■ Development of innovative tools for Ochratoxin A risk assessment (2011-2012)

PI: **Beatriz Prieto** (coordinator)

Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR), Comunitat de Treball dels Prineus (CTP).

■ **LABINCHIP** (2010-2012).

PI: **Josep Samitier**

Centro para el Desarrollo Tecnológico Industria (CDTI), Industria de la Ciencia.

■ **ONCOLOGICA** Nuevas estrategias basadas en biomarcadores para la detección del cáncer, su pronóstico, la predicción de respuesta y el desarrollo de nuevos tratamientos (2009-2012).

PI: **Josep Samitier** (coordinated by PharmaMar)

Centro para el Desarrollo Tecnológico Industria (CDTI), CENIT Industrial project with Genómica, S.A.U.

■ Desarrollo de tecnologías en bionanomedicina para diagnóstico y terapia (2009-2014).

PI: **Josep Samitier**

Fundación Botín.

■ Grup de recerca consolidat (2009-2013).

PI: **Josep Samitier**

Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (SGR 2009).

Publications

■ Urbán, P., Estelrich, J., Cortés, A. and Fernández-Busquets, X. (2011). A nanovector with complete discrimination for targeted delivery to *Plasmodium falciparum*-infected versus non-infected red blood cells *in vitro*. *Journal of Controlled Release*, 151 (2), 202-211

■ Ivon Rodriguez-Villarreal, A., Tarn, M. D., Madden, L. A., Lutz, J. B., Greenman, J., Samitier, J. and Pamme, N. (2011). Flow focussing of particles and cells based on their intrinsic properties using a simple diamagnetic repulsion setup. *Lab on a Chip*, 11 (7), 1240-1248

■ Castillo-Fernandez, O., Salieb-Beugelaar, G. B., van Nieuwkastele, J. W., Bomer, J. G., Arundell, M., Samitier, J., van den Berg, A. and Eijkel, J. C. T. (2011). Electrokinetic DNA transport in 20 nm-high nanoslits: Evidence for movement through a wall-adsorbed polymer nanogel. *Electrophoresis*, 32 (18), 2402-2409

■ Mir, M., Martinez-Rodriguez, S., Castillo-Fernandez, O., Homs-Corbera, A. and Samitier, J. (2011). Electrokinetic techniques applied to electrochemical DNA biosensors. *Electrophoresis*, 32 (8), 811-821

■ Fernandez, J. G., Samitier, J. and Mills, C. A. (2011). Simultaneous biochemical and topographical patterning on curved surfaces using biocompatible sacrificial molds. *Journal of Biomedical Materials Research Part A*, 98A (2), 229-234

■ Rodriguez-Segui, S. A., Pons Ximenez, J. I., Sevilla, L., Ruiz, A., Colpo, P., Rossi, F., Martinez, E. and Samitier, J. (2011). Quantification of protein immobilization on substrates for cellular microarray applications. *Journal of Biomedical Materials Research Part A*, 98A (2), 245-256

■ Urban, P., Estelrich, J., Adeva, A., Cortes, A. and Fernandez-Busquets, X. (2011). Study of the efficacy of antimalarial drugs delivered inside targeted immunoliposomal nanovectors. *Nanoscale Research Letters*, 6 (1), 620

■ Tahirbegi, I. B. and Mir, M. (2011). Slit-wave model for band structures in solid state physics. *Modern Physics Letters B*, 25 (3), 151-161

■ Juanola-Feliu, E., Colomer-Farrarons, J., Miribel-Catala, P., Samitier, J. and Valls-Pasola, J. (2011). Challenges facing academic research in commercializing event-detector implantable devices for an *in vivo* biomedical subcutaneous device for biomedical analysis. *VLSI Circuits and Systems V*, Prague, Czech Republic

■ Valle-Delgado, J. J., Urban, P., Baro, E., Moles, E., Marques, J., Samitier, J. and Fernandez-Busquets, X. (2011). Probing the binding of *Plasmodium falciparum*-infected red blood cells to polysaccharides by force spectroscopy. *7th European Congress on Tropical Medicine and International Health*, Barcelona, Spain

■ Colomer-Farrarons, J., Miribel-Catala, P. L. and Samitier, J. (2011). Low-voltage μ power CMOS subcutaneous biomedical implantable device for true/false applications. *IASTED International Conference Biomedical Engineering (Biomed 2011)*, Innsbruck, Austria

■ Punter-Villagrasa, J., Colomer-Farrarons, J., Miribel-Catala, P., Puig-Vidal, M. and Samitier, J. (2011). Discrete to full custom ASIC solutions for bioelectronic applications. *VLSI Circuits and Systems V*, Prague, Czech Republic

■ Martinez, E. and Samitier, J. (2011). Soft lithography and variants. In *Generating micro- and nanopatterns on polymeric materials* (ed. del Campo, A. and Arzt, E.), 57-66, Wiley-VCH Verlag GmbH, Weinheim

■ Colomer-Farrarons, J., Miribel-Catala, P. L., Rodríguez-Villarreal, A. I. and Samitier, J. (2011). Portable bio-devices: Design of electrochemical instruments from miniaturized to implantable devices. In *New perspectives in biosensors technology and applications* (ed. Andrea Serra, P.), InTech, Rijeka, Croatia

■ Mir, M. (2011). Aptamers: The new biorecognition element for proteomic biosensing. In *Biochemistry Research Updates* (ed. Baginski, S. J.), Nova Science Publishers, Inc., Hauppauge, USA

Collaborations with other research centres

Prof. M. Madou University of California, Irvine (USA).

Dr. Max M. Burger Novartis AG, Basel (Switzerland) and Marine Biological Laboratory, Woods Hole (USA).

Prof. E. Faszewski Wheelock College, Boston (USA).

Prof. G. Fuhr FhG. Biomedicine, St. Ingbert (Germany).

Prof. D. Anselmetti Bielefeld University (Germany).

Prof. H. Börner Max-Planck Institute of Colloids and Interfaces, Golm (Germany).

Dr. Graham Johnson Uniscan Instruments Ltd, Buxton (UK).

Prof. Molly M. Stevens Imperial College, London (UK).

Dr. Matthew Dalby University of Glasgow, Glasgow (UK).

Prof. Daniel Riveline ISIS/IGBMC, Strasbourg (France)

Prof. Andre Bernard MNT- NTB, Buchs (Switzerland)

Dr. Edith Pajot INRA, Jouy-en-Josas (France).

Dr. Christophe Vieu LAAS-CNRS, Toulouse (France).

Dr. Nicole Jaffrezic Université Claude Bernard Lyon 1 (France).

Prof. Jean-Louis Marty Université de Perpignan Via Domitia (France).

Prof. François Rossi JRC-Ispra (Italy).

Prof. Paolo Dario SSSUP, Pisa (Italy).

Prof. M. Sampietro Politecnico di Milano (Italy).

Prof. L. Reggiani INFN, Nanotechnology Laboratory, Lecce (Italy).

Prof. Vasco Teixeira Universidade do Minho, Braga (Portugal).

Prof. Joan Bausells CNM-CSIC, Barcelona (Spain).

Dr. M. Lluïsa Pèrez Dept. Farmacología, University of Barcelona (Spain).

Dr. M^a Pilar Marco IIQAB-CSIC, Barcelona (Spain).

Dr. Juan C. Izpisúa CMRB, Barcelona (Spain).

Dr. Jaume Reventós Hospital Vall d'Hebrón, Barcelona (Spain).

Prof. Albert van den Berg University of Twente (The Netherlands).

Dr. Hernando del Portillo Centro de Investigación en Salud Internacional de Barcelona (CRESIB), Barcelona (Spain).

Prof. Ramón Eritja Institut de Recerca Biomédica (IRB), Barcelona (Spain).

Industrial collaborations:

Genomica S.A.U. (Zeltia group)

Biokit S.A. (Werfen group)

Enantia S.L.

Tallers Fiestas S.L.

Scientific equipment and techniques

■ Nanofabrication and nanomanipulation

- Automatized microcontact printing system (custom-made)
- Dip-Pen Nanolithography system (DPN)
- Nanoplotter NPM
- Nanotechnology Platform (PCB): equipment for hot embossing lithography, polymer processing and photolithography, chemical wet etching, e-beam evaporation

■ Characterization

- Surface Plasmon Resonance (SPR)
- Quartz crystal microbalance (QCM)
- Optical Waveguide Lightmode Spectroscopy (OWLS)
- Atomic Force Microscope (AFM)
- Optical Microscopes (white light/epifluorescence)
- Impedance spectroscopes
- Precision Impedance Analyzer
- Sub-femtoamp Remote SourceMeter Instrument

■ Microfluidics

- High precision syringe pumps
- Peristaltic pumps

■ Molecular/cell biology

- Biological safety cabinet (class II)
- Microwell plate readers
- Protein and DNA electrophoresis systems
- Nanodrop spectrophotometer

Single Molecule Bionanophotonics (until July 2011)

Group leader: Prof. Dr. María García-Parajo

Postdoctoral researchers: Dr. Olga Esteban, Dr. Carlo Manzo

PhD students: Gemma Pérez, Juan Andrés Torreño, Thomas van Zanten

Technician: Merche Rivas



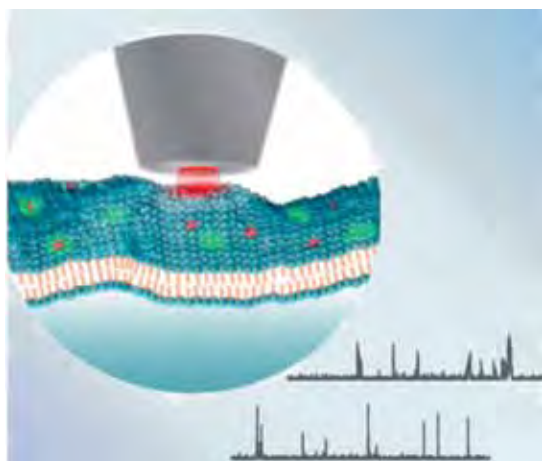
The Single Molecule Bionanophotonics group devotes its research activities to the development and application of cutting-edge optical techniques for the study of biological processes at the single molecular level and on living cells. Thus we aim to develop fluorescence techniques that combine high spatial and temporal resolution for the dual goals of probing and manipulating biological function at the level of single molecules in their native environment: the living cell.

Nanoscale imaging on intact cell membranes is obtained using near-field optical microscopy (NSOM). We also generate strong nanoscale optical fields and superfocusing by fabrication of optical nano-antennas, tuned in resonance with the photon emitters. These nano-antenna probes scanned in controlled proximity to cell membranes allow optical resolution below 30nm. High temporal resolution is achieved using fluorescence correlation spectroscopy (FCS) and Epi/Total internal reflection fluorescence microscopy (TIRF) for single emitter tracking on living cells.

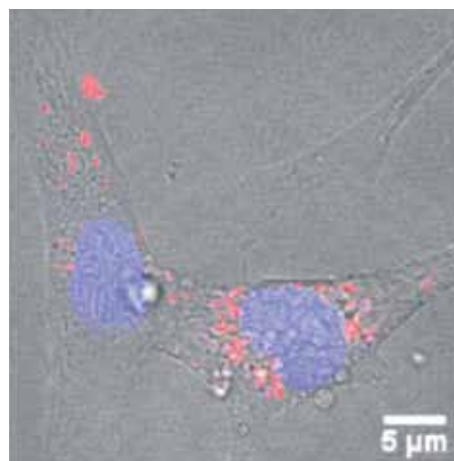
Our aim is to elucidate fundamental biological questions that have important implications for health and disease. Topics that attract our attention in the biological arena are cell membrane compartmentalization at the nanoscale, leukocyte adhesion mediated by integrin receptors and pathogen recognition by cells of the immune system.

As highlights of our achievements in 2011 we demonstrated the feasibility of fluorescence correlation spectroscopy (FCS) based on the nanometric illumination of near-field scanning optical microscopy (NSOM) probes on intact living cells (*Biophys. J.* (2011), 100, L08). NSOM-FCS applied to fluorescent lipid analogs allowed us to reveal details of the diffusion hidden by larger illumination areas. Moreover, the technique offers the unique advantages of evanescent axial illumination and straightforward implementation of multiple colour excitation. In collaboration with the group of Prof. F. Sanz (page 36) we evaluated the potential of functional polyelectrolyte based nanoparticles as nanocarriers for lysosomal delivery of therapeutic proteins (*Biomacromolecules* (2011), 12, 2524). Using high-resolution fluorescence microscopy we characterized at the single particle level the binding, cellular uptake and successful delivery of these nanocarriers to lysosomal compartments.

The Single Molecule Bionanophotonics group left IBEC in July 2011 and now continues its work at the Institut de Ciències Fotòniques (ICFO).



Artist's impression of how a subwavelength aperture probe as used in NSOM locally excites a nanometric region of the cell membrane allowing the recording of fluorescence bursts arising from the diffusion of lipids on the membrane.



Confocal fluorescence micrograph of cells incubated with Atto647N-labeled nanocarriers containing the enzyme α -Gal (red). The image shows the successful uptake of the nanoparticles.

Research projects

■ **IMMUNANOMAP**. Unraveling the Nano-Landscape of Receptors Controlling Molecular Processes of the Immune System (2007-2011).

PI: **María García-Parajo**

IBEC fellows: **Carlo Manzo, Thomas van Zanten**
Marie Curie Research Training Network (MCRTN) within the framework of EU-FP6.

■ **PHOTONICS4LIFE** Network of Excellence for biophotonics (2009-2012).

PI: **María García-Parajo** (cluster partner)

European Network of Excellence (NoE) within the framework of EU-FP7.

■ Single Molecule Bionanophotonics (2009-SGR-597).

PI: **María García-Parajo**

Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (2009-2013).

■ Development of nanomedicines for enzymatic replacement therapy in Fabry disease (2010-2013).

PI: **María García-Parajo** (coordinated by the Hospital Vall d'Hebron)

Fundació La Marató de TV3.

■ **IMMU-NANO-FORCE** Micropatterned biomaterials for nanoscale force-induced activation of adhesion receptors in the immune system (2011).

PI: **María García-Parajo**

MICINN (MAT2010-19898).

Publications

■ Izquierdo-Useros, N., Esteban, O., Rodríguez-Plata, M. T., Erkizia, I., Prado, J. G., Blanco, J., García-Parajo, M. F. and Martínez-Picado, J. (2011). Dynamic imaging of cell-free and cell-associated viral capture in mature dendritic cells. *Traffic*, 12 (12), 1702-1713

■ Manzo, C., van Zanten, T. S. and García-Parajo, M. F. (2011). Nanoscale fluorescence correlation spectroscopy on intact living cell membranes with NSOM probes. *Biophysical Journal*, 100 (2), L8-L10

■ Giannotti, M. I., Esteban, O., Oliva, M., García-Parajo, M. F. and Sanz, F. (2011). pH-Responsive polysaccharide-based polyelectrolyte complexes as nanocarriers for lysosomal delivery of therapeutic proteins. *Biomacromolecules*, 12 (7), 2524-2533

■ Manzo, C., van Zanten, T. S. and García-Parajo, M. F. (2011). Nanoscale fluorescence correlation spectroscopy on intact living cell membranes with NSOM probes. *8th EBSA European Biophysics Congress*, Budapest, Hungary

■ van Zanten, T. S., Gomez, J., Manzo, C., Cambi, A., Buceta, J., Reigada, R. and García-Parajo, M. F. (2011). Direct mapping of nanoscale compositional connectivity on intact cell membranes. *8th EBSA European Biophysics Congress*, Budapest, Hungary

- van Zanten, T. S. and Garcia-Parajo, M. F. (2011). Near-field scanning optical microscopy of biological membranes. In *Life at the Nanoscale: Atomic Force Microscopy of Live Cells* (ed. Dufrene, Y.). Pan Stanford Publishing Pte Ltd, Singapore, 185-207

Collaborations with other research centres

Prof. Carl G. Figdor Nijmegen Centre for Molecular Life Sciences (NCMLS), Nijmegen (The Netherlands).

Prof. Peter Hinterdorfer Biophysics Institute, Johannes Kepler University, Linz (Austria).

Prof. Vincenzo Cerundolo Weatherall Institute of Molecular Medicine, University of Oxford (UK).

Prof. Vinod Subramaniam BPE group, University of Twente (The Netherlands).

Prof. Niek van Hulst Institut de Ciències Fotòniques (ICFO), Barcelona (Spain).

Prof. Jennifer Herek Optical Sciences group, MESA+, University of Twente (The Netherlands).

Dr. Javier Martínez-Picado IrsiCaixa Foundation, Hospital Germans Trias i Pujol, Badalona (Spain).

Scientific equipment and techniques

- Aperture type near-field optical microscopy (NSOM) working under aqueous conditions
- Single-molecule-detection-sensitive scanning confocal microscopy: imaging, polarization, and wavelength sensitive
- Dual-colour wide-field/TIRF fluorescence microscopy equipped with dual colour detection (EM-CCD camera) and environmental chamber for live cell experiments
- Multi-parametric single-molecule confocal (Microtime 200) combined with epi-TIRF excitation and dual colour detection (EM-CCD camera) and liquid cell, temperature and CO₂-controlled for live cell experiments
- Lasers: several helium-neon (He-Ne), argon/krypton (Ar/Kr+), ps-lasers

Nanoscale Bioelectrical Characterization

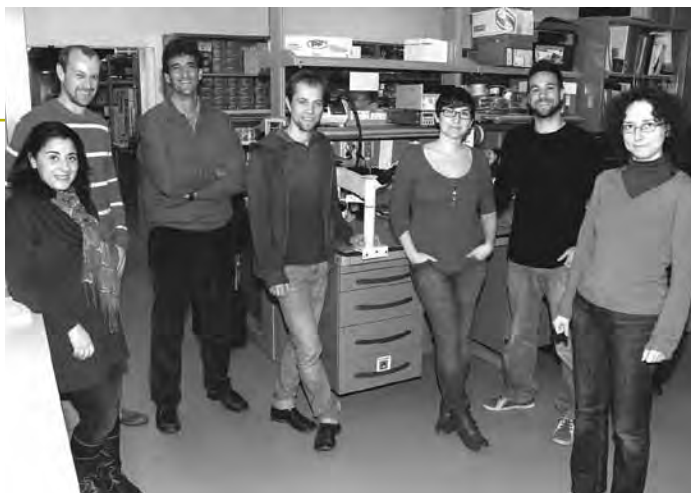
Group leader: Dr. Gabriel Gomila

Senior researcher: Dr. Laura Fumagalli

Postdoctoral researchers: Dr. Annalisa Calò, Dr. Martin Edwards

PhD students: Aurora Dols-Pérez, Daniel Esteban, Georg Gramse

Masters student: Payman Mosaffa



The main goal of our research group is to develop new experimental setups based on atomic force microscopy and theoretical frameworks enabling us to measure and understand the electrical properties of biological samples at the nanoscale (for example, biomembranes, single biomolecules and single cells). Our main objective is to contribute to the development of new label-free biological characterization methods and of electronic biosensors.

During 2011 we have extended the applicability of quantitative electrostatic force microscopy to biosystems with non-planar geometries. Ongoing work in advanced stages of development includes the analysis of the nanoscale dielectric properties of single bacteria and of single dielectric nanoparticles. Moreover, we have advanced significantly in extending quantitative electrostatic force microscopy to liquid environments, in understanding the adsorption of natural nanovesicles containing olfactory receptors onto solid supports for biosensor applications, and in preparing heterogeneous supported lipid bilayers stable in air to be used as model systems.

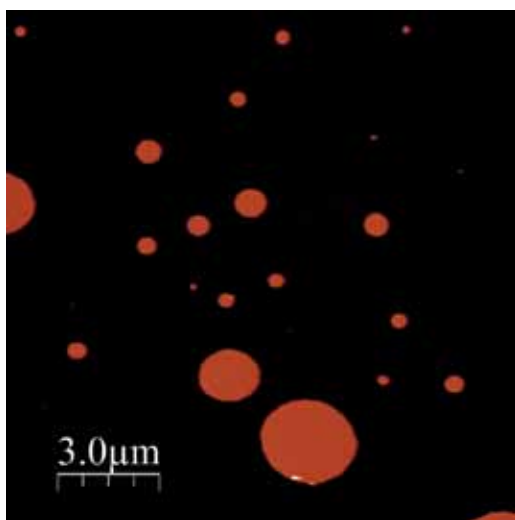
Research projects

■ **ELECTROBACTERIA** Nanotools and nanotechniques for bioelectric studies in single bacteria cells (2011-2013).
PI: **Gabriel Gomila**
MICINN (TEC2010-16844).

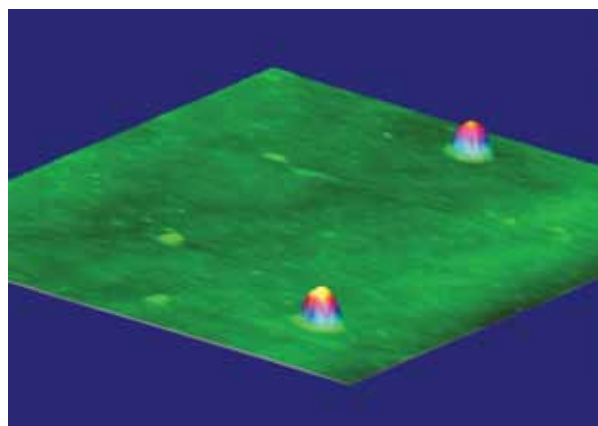
■ **AFM4NanoMed&Bio** European network on applications of Atomic Force Microscopy to NanoMedicine and Life Sciences (2010-2015).
PI: **Gabriel Gomila** (Management Committee Substitute Member)
EU COST Action TD1002.

■ **BOND** Bioelectronic Olfactory Neuron Device (2009-2013).
Technical Manager: **Gabriel Gomila**
Coordinator: **Josep Samitier** (for the UB; see page 34)
Collaborative project (NMP) within the framework of EU-FP7.

■ Ayuda para la intensificación de la actividad de la investigación (2008-2010).
PI: **Gabriel Gomila** (under UB)
MEC-Generalitat de Catalunya, Programa I3.



Topographic atomic force microscopy image of a spin-coated DOPC lipid layer on a mica substrate stable in dry air environment. We have demonstrated that the background in the image corresponds to a single lipid monolayer around 1.3 nm thick, while the patches correspond to an inverted lipid bilayer around 4.5 nm thick.



Topographic atomic force microscopy image of two natural membrane nanovesicles adsorbed on a glass substrate and imaged under physiological buffer. The membrane nanovesicles were obtained from the disruption of yeast cells expressing olfactory receptors. We have demonstrated that nanovesicles upon adsorption on the substrate flatten to an aspect ratio around 0.1 but remain closed.

Publications

■ Dols-Perez, A., Fumagalli, L., Cohen Simonsen, A. and Gomila, G. (2011). Ultrathin spin-coated dioleoylphosphatidylcholine lipid layers in dry conditions: A combined atomic force microscopy and nanomechanical study. *Langmuir*, 27 (21), 13165-13172

Collaborations with other research centres

Prof. Adam Cohen Simonsen Department of Physics and Chemistry, University of Southern Denmark (Denmark).

Prof. Jose L. Carrascosa Department of Structure of Macromolecules, Centro Nacional de Biotecnología, Madrid (Spain).

Prof. Joan Bausells Centro Nacional de Microelectrónica-CSIC, Barcelona (Spain).

Prof. Edith Pajot-Augy Neurobiologie de l'olfaction et la prise alimentaire, Institut National de la Recherche Agronomique, Jouy-en-Josas (France).

Dr. Manel Puig Departament d'Electrònica, University of Barcelona (Spain).

Prof. Marco Sampietro Laboratorio di Strumentazione Analogica e Materiali Polimerici, Politecnico di Milano (Italy).

Dr. Adriana Gil Nanotec Electronica SL, Madrid (Spain).

Prof. Lino Reggiani National Nanotechnology Laboratory, Università di Salento, Lecce (Italy).

Scientific equipment and techniques

- Portable electrochemical interface and impedance analyser (Ivium Technologies, CompactStat)
- Digital lock-in amplifier (Zurich Instruments HF2LI)
- Two digital 4-phase Lock-In amplifiers (Anfatec eLockIn204)
- Two Atomic Force Microscopes fully customized for DC and AC electric current and electrostatic force detection (Nanotec Electronica S.L.)
- Sub-femtoAmp remote sourcemeter (Keithley 6430)
- Optical Microscope (Zeiss AxioImager)
- Atomic Force Microscope for imaging and electrostatic force detection (Nanosurf easyScan 2)

Bio/Non-Bio Interactions for
Regenerative Medicine

Prof. Dr. Josep A. Planell



Molecular Dynamics at Cell–
Biomaterial Interface

Prof. Dr. George Altankov



Biomechanics and
Mechanobiology

Dr. Damien Lacroix



Biomaterials, implants and tissue
engineering programme

Bio/non-bio Interactions for Regenerative Medicine

Group leader: Prof. Dr. Josep A. Planell

Senior researcher: Dr. Elisabeth Engel, Dr. Oscar Castaño, Dr. Miguel Angel Mateos, Dr. Melba Navarro

PhD students: Zaida Álvarez, Arlyng González, Riccardo Levato, Marta Mattotti, Xavier Puñet, Nadège Sachot, Aitor Sánchez, Tiziano Serra

Masters students: Laura Corredor, Juan Crespo, Daniel García, José Luís García

Undergraduates: Nunzia Di Luise, David Miranda Nieves, Laia Gil, Marina Tantinyà, Joaquim Viñes

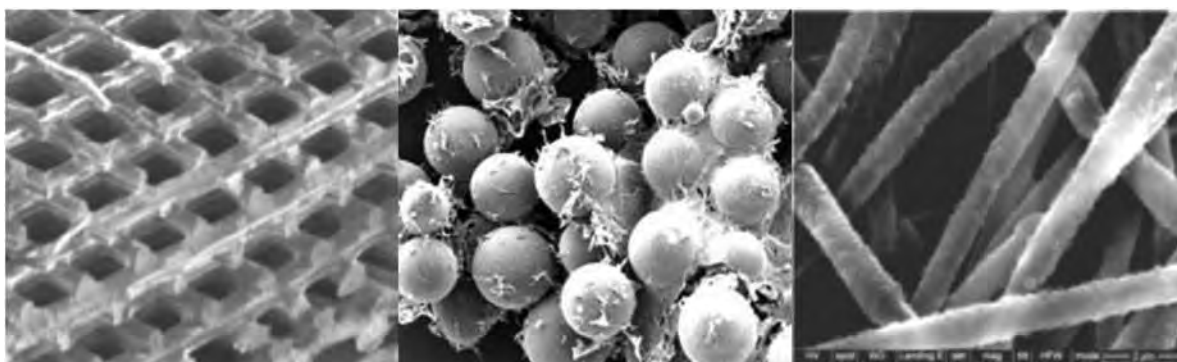
Technicians: Belén González

Visitors: Catarina Almeida, Aurelio Salerno, Jong Eun Won



The research activities of the Bio/non-bio Interactions for Regenerative Medicine group are focused on the development of new biomaterials for tissue regeneration. Bioactive and biodegradable materials are studied and both fundamental and applied knowledge on their interactions with biological entities are developed to enable tissue engineering, which consists of the repair and the functional restoration of tissues or organs by means of 3D scaffolds, cells and signals. In order to fulfil its scientific strategy, the research group masters its own fabrication techniques of 3D scaffolds with tailored geometry and mechanical properties, as well as its own methods of surface functionalization with different biochemical cues to signal the biological environment. It also has the capacity to isolate and culture stem and precursor cells for the *in vitro* biological characterization of scaffolds and the development of tissue engineered constructs.

In 2011, important progress was made in all these topics. The group advanced in the synthesis of new materials; in particular, blended bioactive ormoglass/polylactic acid hybrids with both angiogenic and osteogenic potential were obtained. Regarding the fabrication of 3D scaffolds, electrospun polymer fibres with covalently bonded bioactive coatings were achieved. New protocols for the fabrication of rapid prototyping (RP) scaffolds with well-defined and reproducible architectures were set for various polymers. In addition, a new method to fabricate biodegradable micro- and nanoparticles without involving toxic chemicals was successfully accomplished, and a functionalisation method was developed to introduce biomolecules to the surface of nanofibers, RP scaffolds and microparticles in order to provide cells with the right signals. The combination of these controlled manufacturing processes, together with biofunctionalisation, has been tuned for different clinical applications such as ophthalmology, the nervous system, skin and bone.

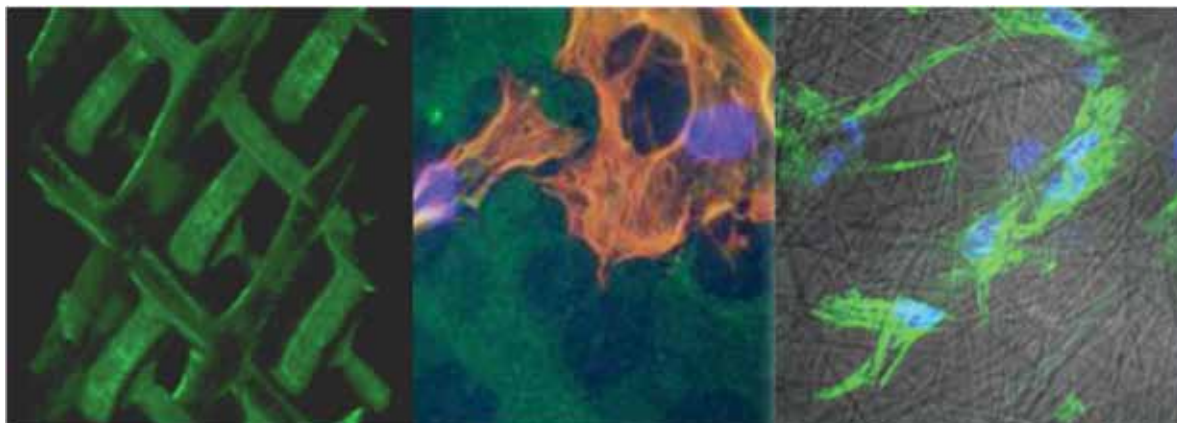


Three-dimensional biodegradable Rapid Prototyping scaffold (left); biodegradable polymeric microparticles (centre); hybrid electrospun nanofibres (right).

In the biological field, the effect of biomaterials' ionic release on progenitor cells homing, proliferation and differentiation was demonstrated. In particular, the stimulation of angiogenesis and osteogenesis and up-regulation of key genes on bone and vessels formation was shown. Electrospun PLA fibres implanted in rats brain cortex were found to support neuron colonization and to promote capillary formation.

From 2012 the Bio/Non-Bio Interactions for Regenerative Medicine group will be known as the Biomaterials for Regenerative Therapies group. The new name better reflects the aims and scientific strategy of the group, whose strength lies in the development of smart biomaterials to achieve a successful regeneration of tissues or organs.

Biofunctionalized rapid prototyping scaffold (left); rat mesenchymal stem cells spread on polymeric microparticles (centre); rat mesenchymal stem cells attached to hybrid electrospun fibres.



Research projects

■ **ANGIOSCAFF** Highly Porous Bioactive Scaffolds Controlling Angiogenesis for Tissue Engineering (2008-2012).

PI: **Josep A. Planell**

Other group leaders involved: **Damien Lacroix** (page 60)
Collaborative project within the framework of EU-FP7.

■ **DISC REGENERATION** Novel Biofunctional High Porous Polymer Scaffolds and Techniques Controlling Angiogenesis for the Regeneration and Repair of the Degenerated Intervertebral Disc (2008-2012).

PI: **Josep A. Planell**

Other group leaders involved: **Damien Lacroix** (page 60)
Collaborative project within the framework of EU-FP7.

■ **BIOFUSS** Materiales biofuncionalizados para reparación y regeneración de tejidos (2009-2011).

PI: **Josep A. Planell**

Other group leaders involved: **Damien Lacroix** (page 60)
MICINN, Investigación fundamental no orientada.

■ Evaluación biológica de materiales bioactivos, biomiméticos y multifuncionales para la regeneración ósea (2010-2012).

PI: **Elisabeth Engel**

MICINN, Investigación fundamental no orientada.

■ Grup de recerca consolidat (2009-2013).

PI: **Josep A. Planell**

Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (SGR 2009).

■ **VALOR** Development of a wound dressing for the treatment of vascular ulcers that promotes revascularization and tissue regeneration (2011-2013).

PI: **Melba Navarro**

Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Ajuts destinats a incentivar els projectes i les activitats de valorització de recerca i de tecnologia (VALOR 2010).

■ Study of the *in vitro* inflammatory response of biodegradable scaffolds for tissue engineering (2011-2013).

PI: **Melba Navarro**

MICINN, Acción Integrada (Portugal).

Publications

■ Gustavsson, J., Ginebra, M. P., Engel, E. and Planell, J. (2011). Ion reactivity of calcium-deficient hydroxyapatite in standard cell culture media. *Acta Biomaterialia*, 7 (12), 4242-4252

■ Perut, F., Montufar, E. B., Ciapetti, G., Santin, M., Salvage, J., Traykova, T., Planell, J. A., Ginebra, M. P. and Baldini, N. (2011). Novel soybean/gelatine-based bioactive and injectable hydroxyapatite foam: Material properties and cell response. *Acta Biomaterialia*, 7 (4), 1780-1787

■ Noailly, J., Planell, J. and Lacroix, D. (2011). On the collagen criss-cross angles in the annuli fibrosi of lumbar spine finite element models. *Biomechanics and Modeling in Mechanobiology*, 10 (2), 203-219

■ Rodríguez-Hernández, A., Juárez, A., Engel, E. and Gil, F. (2011). *Streptococcus sanguinis* adhesion on titanium rough surfaces: effect of shot-blasting particles. *Journal of Materials Science: Materials in Medicine*, 22 (8), 1-10

■ Pegueroles, M., Aguirre, A., Engel, E., Pavon, G., Gil, F. J., Planell, J. A., Migonney, V. and Aparicio, C. (2011). Effect of blasting treatment and F_n coating on MG63 adhesion and differentiation on titanium: a gene expression study using real-time RT-PCR. *Journal of Materials Science-Materials in Medicine*, 22 (3), 617-627

■ Montufar, E. B., Traykova, T., Planell, J. A. and Ginebra, M.-P. (2011). Comparison of a low molecular weight and a macromolecular surfactant as foaming agents for injectable self setting hydroxyapatite foams: Polysorbate 80 versus gelatine. *Materials Science and Engineering: C*, 31 (7), 1498-1504

■ Serra, T., Navarro, M. and Planell, J. (2011). Fabrication and characterization of biodegradable composite scaffolds for tissue engineering. In *Innovative Developments in Virtual and Physical Prototyping: Proceedings of the 5th International Conference on Advanced Research in Virtual and Rapid Prototyping*. (ed. Bartolo, P. J.), CRC Press, Leira, Portugal

Collaborations with other research centres

Dr. Joelle Amedee INSERM, Bordeaux (France).

Dr. Soledad Alcántara Grup de Desenvolupament Neural, IDIBELL, University of Barcelona (Spain).

Dr. Luigi Ambrosio Centro di Ricerca Interdipartimental Biomateriali, Università di Napoli (Italy).

Dr. Mateo Santin School of Pharmacy and Biomolecular Sciences, University of Brighton (UK).

Dr. Jeffrey Hubbell Institute of Bioengineering, École Polytechnique Fédérale de Lausanne (Switzerland).

Dr. José Carlos Rodríguez-Cabello Dept. de Física de la Materia Condensada, Universidad de Valladolid (Spain).

Dr. Juan Rojo Universidad Complutense de Madrid (Spain).

Dr. Julio San Román Dept. of Biomaterials, Institute of Polymer Science and Technology, CSIC, Madrid (Spain).

Dr. Manuel Doblaré Group of Structural Mechanics and Materials Modelling, Institute of Engineering Research (I3A), Universidad de Zaragoza (Spain).

Dr. Margarita Calonge Institute of Ophthalmobiology (IOBA), Universidad de Valladolid (Spain).

Dra. Anita Ignatius Institut für Unfallchirurgische Forschung und Biomechanik, University of Ulm (Germany).

Dr. Francisco Blanco Complejo Universitario Juan Canalejo, La Coruña (Spain).

Dr. Julia Buján Dept. de Ciencias Morfológicas y Cirugía, Facultad de Medicina, Universidad de Alcalá de Henares (Spain).

Dr. Matilde Alonso Dept. de Física de la Materia Condensada, Universidad de Valladolid (Spain).

Dr. María Vallet Regí Facultad de Farmacia, Universidad Complutense de Madrid (Spain).

Dr. Jerónimo Blanco Institut de Ciències Cardiovasculars de Catalunya and CSIC, Barcelona (Spain).

Dr. Álvaro Mata PCB Nanotechnology Platform, Barcelona (Spain).

Dr. Mário Barbosa Instituto Nacional de Engenharia Biomédica (INEB), Oporto (Portugal).

Prof. Francesco Serino Department of Vascular Surgery, Istituto Dermatologico dell'Immacolata (IDI), Rome (Italy).

Prof. James Kirkpatrick Institute of Pathology, Johannes Gutenberg University, Mainz (Germany).

Dr. Nick Rhodes Dept. of Clinical Engineering, University of Liverpool (UK).

Prof. Hae-Won Kim Institute of Tissue Regeneration Engineering (ITREN), Dankook University, Cheonan (South Korea).

Dr. Izabella Rajzer Institute of Textile Engineering and Polymer Materials, University of Bielsko-Biala, Bielsko-Biala (Poland).

Dr. Małgorzata Lewandowska Faculty of Materials Science & Engineering, WUT Warsaw University of Technology (Poland).

Dr. José Becerra Ratia Dept. Biología Celular, Genética y Fisiología, Universidad de Málaga (Spain).

Dr. José Antonio Andrades Gómez Dept. Biología Celular, Genética y Fisiología, Universidad de Málaga (Spain).

José Ramón Sarasua Biopolymers and Thermoplastics Materials Group, University of the Basque Country (EHU-UPV) (Spain).

Scientific equipment and techniques

- Surface characterization equipment (contact angle, Z potential, quartz crystal microbalance, nanoindenter)
- Cell culture facilities
- Molecular Biology equipment: protein and DNA electrophoresis
- Thermocycler (PCR)
- Rapid prototyping tool
- Peptide synthesiser
- Combustion furnace
- Electrospinning device
- Spin-coater
- Vibrational viscosimeter
- Ion selective electrodes for Ca^{2+} , Na^{+} , K^{+} , and pH
- ElectroForce® BioDynamic® test instrument

Molecular Dynamics at Cell-Biomaterial Interface

Group leader: Prof. Dr. George Altankov

Postdoctoral researchers: Marco Cantini, Johan Gustavson

PhD students: Dencho Milkov Gugutkov, Nuno Miranda Guerra Coelho, Georgi Toromanov

Undergraduate: Ulrich Spengler

Technician: Olga Zhukova

Visitor: Gianvito Lovero



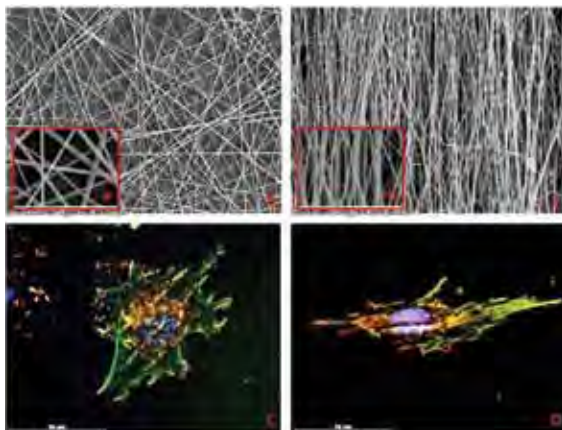
What cells recognize, secrete and remodel at the biomaterials interface is the provisional extracellular matrix. How it relates to the biocompatibility of materials and how we can control these processes from the materials site is the main topic of our research. We aim to control matrix protein remodelling at the cell-material interface by engineering the material properties.

We perform systematic studies in the following directions:

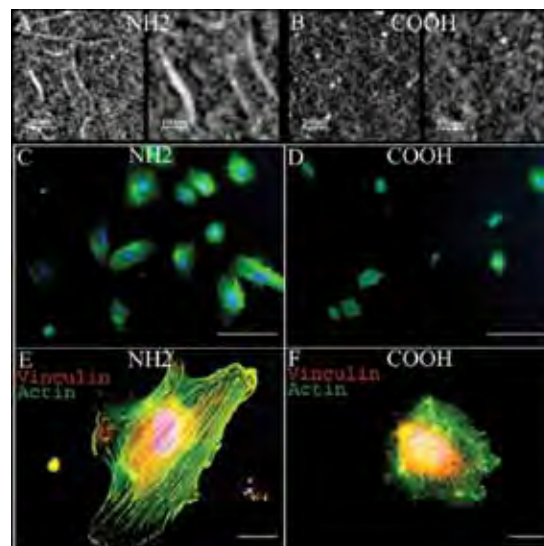
- Materials surface driven assembly of ECM proteins at the nanoscale;
- Cellular interaction with biomimetic nanostructures and networks;
- Electrospinning of nanofibres from natural and synthetic polymers for guiding cellular behaviour;
- Remodeling of ECM proteins at cell-biomaterials interface;
- Integrin dynamics.

ECM remodelling occurs in various physiological and pathological processes, such as normal development, wound healing and angiogenesis, but also in atherosclerosis, fibrosis, ischemic injury and cancer. It consists of two fundamental processes, assembly and degradation. ECM organisation at the biomaterial interface depends on the allowance of cells to rearrange adsorbed matrix proteins; we anticipated that materials that bind proteins loosely will support the arrangement of a provisional ECM. However, the ECM undergoes also proteolytic degradation, which is a physiological mechanism for the removal of excess ECM.

Even though matrix remodelling is a subject of extensive biomedical research, the way it is related to the biocompatibility of materials is poorly understood. Recently we have employed distinct silane chemistries and polymer compositions to create model substrates with tailored density of OH, COOH, NH₂ and CH₃ groups, thus varying in their chemistry, charge and hydrophilic/hydrophobic balance. In a series of communications combining AFM and other nanoindentation techniques, we have described a novel phenomenon of substratum-driven protein assembly depicting the fate of various matrix proteins such as fibronectin, collagen IV, vitronectin and fibrinogen at the above model



Novel type of hybrid PLA-fibrinogen nanofibres deposited as random (a) or aligned (b). It was shown that they induce distinct functional response in endothelial cells, which acquire either stellate (c) or elongated (d) morphology, respectively (Gugutkov *et al*, 2011).



AFM images of adsorbed collagen type IV on NH₂ (A) and COOH (B) model surfaces. They are shown on the upper panel in two magnifications that increase from left to right. Adsorption concentration is 50 mg/ml. The middle panel represents the overall morphology of endothelial cells adhering for 2 hours on the same substrata (C vs. D). On the lower panel the single cells are stained simultaneously for actin and vinculin to show the alterations in the focal adhesion complexes on COOH (E vs. F) (Coelho *et al*, 2011).

biomaterials interfaces. We show that with varying the density of chemical functions we can tailor both the assembly and degradation of proteins; we aim to obtain a control on ECM remodelling by engineering the material properties. On the other hand, proteins can form objects of various shapes, and a fascinating possibility is to make nanofibres. We further anticipated that the organization of nanofibres might be used for guiding the cellular behaviour; therefore we electrospun nanofibres from some natural (fibrinogen) and synthetic (PLA) polymers and successfully employed them for this purpose.

Research projects

■ **FIBROGEL** Bioinspired Nanofibrous Gel for Tissue Engineering of Cartilage and Bone (2010-).

PI: **George Altankov**

MICINN, Proyectos Internacionales, European-Latin American Network for Science and Technology (EULANEST).

■ **MATIX DYNAMICS** Dinámica de las proteínas de la matriz en la interfase célula-material (2009-2012).

PI: **George Altankov**

MICINN, Investigación fundamental no orientada.

Publications

- Miranda Coelho, N., Gonzalez-Garcia, C., Salmeron-Sanchez, M. and Altankov, G. (2011). Arrangement of type IV collagen on NH₂ and COOH functionalized surfaces. *Biotechnology and Bioengineering*, 108 (12), 3009-3018
- Hristova, K., Pecheva, E., Pramatarova, L. and Altankov, G. (2011). Improved interaction of osteoblast-like cells with apatite-nanodiamond coatings depends on fibronectin. *Journal of Materials Science - Materials in Medicine*, 22 (8), 1891-1900
- Perez, R. A., Del Valle, S., Altankov, G. and Ginebra, M. P. (2011). Porous hydroxyapatite and gelatin/hydroxyapatite microspheres obtained by calcium phosphate cement emulsion. *Journal of Biomedical Materials Research Part B-Applied Biomaterials*, 97B (1), 156-166
- Miranda Coelho, N., Gonzalez-Garcia, C., Salmeron-Sanchez, M. and Altankov, G. (2011). Arrangement of type IV collagen and laminin on substrates with controlled density of -OH groups. *Tissue Engineering Part A*, 17 (17-18), 2245-2257
- Gugutkov, D., Gonzalez-Garcia, C., Altankov, G. and Salmeron-Sanchez, M. (2011). Fibrinogen organization at the cell-material interface directs endothelial cell behavior. *Journal of Bioactive and Compatible Polymers*, 26 (4), 375-387

Collaborations with other research centres

National University of La Plata (Argentina).

Federal University of Rio de Janeiro (Brazil).

Center for Biomaterials, Technical University of Valencia (Spain).

Bulgarian Academy of Sciences: Institute for Biophysics and Institute of Solid State Physics, Sofia (Bulgaria).

Institute of Pharmacy, Martin Luther University, Halle (Saale) (Germany).

Scientific equipment and techniques

- Facilities for cell culturing
- Universal fluorescent microscope for performing dynamic studies with living cells
- Flow chamber for measuring the strength of cell adhesion
- Electrospinning device for production of nanofibres from various natural and synthetic polymers
- Complete chromatographic and electrophoretic equipment

Biomechanics and Mechanobiology

Group leader: Dr. Damien Lacroix

Postdoctoral researchers: Jérôme Noailly, Cécile Perrault

PhD students: Sara Barreto, Aura María Cardona, Andrea Malandrino, Andy Olivares, Carlos Ruiz, Clara Sandino, Themis Tomanidou

Masters students: Edouard Fulchin, Antonio José Sánchez, Natalia Valencia

Technicians: Rafael López



The focus of the Biomechanics and Mechanobiology research group is the study of the effect of mechanical stimuli on biological response. The group's objective is to make scientific advancements in simulations of *in vitro* and *in vivo* biomechanics and mechanobiology and in experimental *in vitro* mechanobiology. The current focus of the group is mainly on the development of simulations in spine biomechanics, tissue engineering and cell mechanics. These numerical simulations based on the finite element method are complemented with *in vitro* tests using bioreactors and microfluidic chambers.

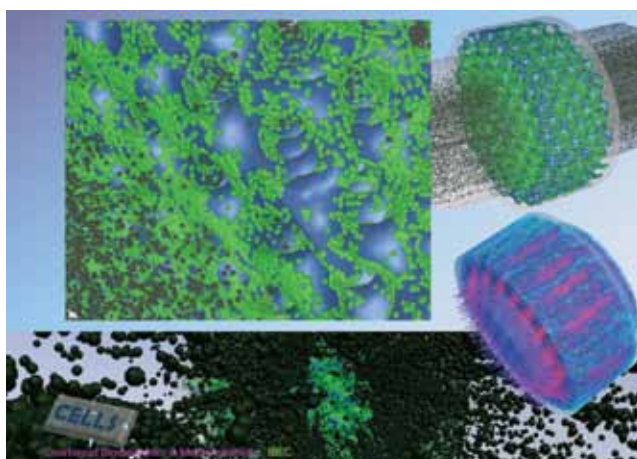
In 2011, major progress was made in all these areas of interest. In tissue engineering, an integrative collaborative study of cell adhesion in rapid prototyping scaffolds in which our group developed a computational fluid dynamics study has shown that the shear stress distribution in the wall of the scaffolds could be related to *in vitro* cell adhesion (*Biomaterials* 32, 2878-2884). This major result highlighted the importance of the local stimuli instead of looking at the global pore size distribution (*Acta Biomaterialia* 7, 478-484).

A new micro-finite element study of an irregular scaffold was also able to predict tissue formation in a calcium phosphate scaffold (*Biomechanics and Modeling in Mechanobiology* 10, 465-476). Related work in orthopaedics in the group successfully predicted fracture healing in a 3D model of the tibia (*J. Orth. Res.* 29, 1496-1503) and studied for the first time the stress distribution in the donning procedure of a prosthetic transfemoral socket (*Annals of Biomedical Engineering* 39, 2972-2983).

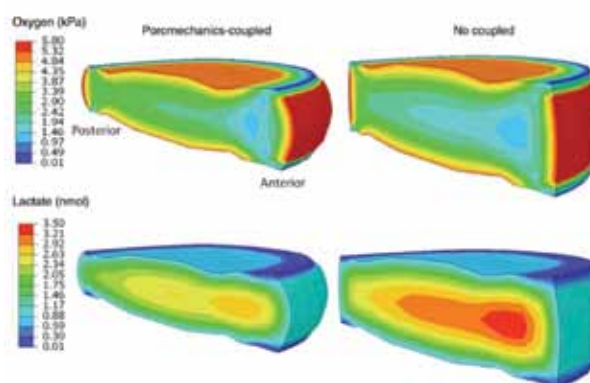
In spine biomechanics the effect of changes of collagen criss-cross angles in the annuli fibrosi of lumbar spine was studied (*Biomechanics and Modeling in Mechanobiology* 10, 203-219). A comparison of four methods to simulate swelling in poroelastic finite element models of intervertebral discs was performed (*J. Mechanical Behavior of Biomedical Materials* 4, 1234-1241). For the first time coupling between mechanical loading and solutes (oxygen and lactate) transport in the intervertebral disc was developed to study their effect on disc degeneration (*PLOS Computational Biology* 7, 8 1-12).

In the area of cell mechanics, progress has been made in the development of a single cell finite element model and in the study of the effect of microfluidic flow on cell attachment.

Finally, during 2011 Damien Lacroix was awarded a European Research Council Starting Grant (MECHANOBIO ERC-2010-StG_20091028) on finite element simulations of tissue engineering. This project started in October 2011 and will last five years.



Simulation of cells flowing in the cell medium and attaching on the scaffold.



Distributions of the interdependent oxygen and lactate concentrations in the intervertebral disc.

Research projects

- **MySpine** Functional prognosis simulation of patient-specific spinal treatment for clinical use (2011-2014)
PI: **Damien Lacroix**
Collaborative project within the framework of EU-FP7.
- **MECHANOBIO** Finite element simulations of mechanobiology in tissue engineering (2011-2016)
PI: **Damien Lacroix**
European Research Council Starting Grant.
- **ANGIOSCAFF** Highly Porous Bioactive Scaffolds Controlling Angiogenesis for Tissue Engineering (2008-2012).
Damien Lacroix (PI: **Josep A. Planell**)
Collaborative project within the framework of EU-FP7.
- **DISC REGENERATION** Novel Biofunctional High Porous Polymer Scaffolds and Techniques Controlling Angiogenesis for the Regeneration and Repair of the Degenerated Intervertebral Disc (2008-2012).
Damien Lacroix (PI: **Josep A. Planell**)
Collaborative project within the framework of EU-FP7.
- **BIOFUSS** Materiales biofuncionalizados para reparación y regeneración de tejidos (2009-2011).
Damien Lacroix (PI: **Josep A. Planell**)
MICINN, Investigación fundamental no orientada.
- **SEVBIOM** Mechanistic and Evolutive Development of Spine Biomechanical Modelling (2009-2011).
PI: **Damien Lacroix**
Fellow: **Jérôme Noailly**
Marie Curie Action (ERG) within the framework of EU-FP7.

- Virtual Physiological Human NoE (2008-2011).
PI: **Damien Lacroix** (cluster partner)
European NoE within the framework of EU-FP7.
- Estudio micromecánico por elementos finitos de la columna lumbar (2009-2010).
PI: **Damien Lacroix**
MICINN, Acciones Integradas.
- Biomechanical study of coxarthrosis in young adults (2010-2011).
PI: **Damien Lacroix**
Funded project with Hospital de Sant Pau, Barcelona.

Publications

- Melchels, F. P. W., Tonnarelli, B., Olivares, A. L., Martin, I., Lacroix, D., Feijen, J., Wendt, D. J. and Grijpma, D. W. (2011). The influence of the scaffold design on the distribution of adhering cells after perfusion cell seeding. *Biomaterials*, 32 (11), 2878-2884
- Malandrino, A., Noailly, J. and Lacroix, D. (2011). The effect of sustained compression on oxygen metabolic transport in the intervertebral disc decreases with degenerative changes. *Plos Computational Biology*, 7 (8), 1-12
- Bohner, M., Loosli, Y., Baroud, G. and Lacroix, D. (2011). Commentary: Deciphering the link between architecture and biological response of a bone graft substitute. *Acta Biomaterialia*, 7 (2), 478-484

- Galbusera, F., Schmidt, H., Noailly, J., Malandrino, A., Lacroix, D., Wilke, H. J. and Shirazi-Adl, A. (2011). Comparison of four methods to simulate swelling in poroelastic finite element models of intervertebral discs. *Journal of the Mechanical Behavior of Biomedical Materials*, 4 (7), 1234-1241
- Noailly, J., Planell, J. and Lacroix, D. (2011). On the collagen criss-cross angles in the annuli fibrosi of lumbar spine finite element models. *Biomechanics and Modeling in Mechanobiology*, 10 (2), 203-219
- Sandino, C. and Lacroix, D. (2011). A dynamical study of the mechanical stimuli and tissue differentiation within a CaP scaffold based on micro-CT finite element models. *Biomechanics and Modeling in Mechanobiology*, 10 (4), 565-576
- Byrne, D. P., Lacroix, D. and Prendergast, P. J. (2011). Simulation of fracture healing in the tibia: Mechanoregulation of cell activity using a lattice modeling approach. *Journal of Orthopaedic Research*, 29 (10), 1496-1503
- Lacroix, D. and Ramirez Patino, J. F. (2011). Finite Element Analysis of Donning Procedure of a Prosthetic Transfemoral Socket. *Annals of Biomedical Engineering*, 39 (12), 2972-2983

Collaborations with other research centres

Dr. Màrius Valera Hospital de la Santa Creu i Sant Pau, Barcelona (Spain).

Prof. Alejandro Frangi Universitat Pompeu Fabra, Barcelona (Spain).

Prof. Péter Pál Varga National Center for Spinal Disorders, Budapest (Hungary).

Dr Ignacio Proubasta Hospital de Sant Pau, Barcelona (Spain).

Prof. Matteo Santin University of Brighton (UK).

Prof. Christian Hellmich Vienna University of Technology, Institute for Mechanics of Materials and Structures, Vienna (Austria).

Prof. Ralph Mueller ETH Zurich (Switzerland).

Prof. Luigi Ambrosio Institute of Composite and Biomedical Materials, National Research Council of Italy, Naples (Italy).

Prof. Marie-Christine Ho Ba Tho Compiègne University of Technology, Compiègne (France).

Prof. Keita Ito Eindhoven University of Technology, Eindhoven (The Netherlands).

Prof. Hans-Joachim Wilke Institute of Orthopaedic Research and Biomechanics, University of Ulm (Germany).

Prof. Patrick Prendergast Trinity Centre for Bioengineering, Trinity College (Ireland).

Scientific equipment and techniques

- High performance computing infrastructure (32 cores, 240 GB RAM and a 11TB disc space)
- Access to the Centre of Supercomputing of Catalonia (CESCA)
- Bose ElectroForce BioDynamic bioreactor system
- Microfluidic chamber
- Image reconstruction software (Simpleware)
- Perfusion bioreactor system
- Finite element software (Abaqus, Fluent, TDyn, MSC Marc)

Biomedical signal
processing and
interpretation

Prof. Dr. Raimon Jané



Artificial Olfaction

Dr. Santiago Marco



Medical signals and
instrumentation programme

Biomedical signal processing and interpretation

Group leader: Prof. Dr. Raimon Jané

Senior researchers: Dr. José Antonio Fiz, Dr. Beatriz Giraldo, Dr. Abel Torres

Postdoctoral researchers: Dr. Ainara Garde, Dr. Christian Morgenstern, Dr. Jordi Solà-Soler

PhD students: Joana Mesquita, Leonardo Sarlabous, Oiane Urria

Masters students: Alejandro Calvo, Mirella López, Beatriz Martínez

Research technicians: Maria Puy Ruiz de Alda, Manuel Lozano, David Montilla



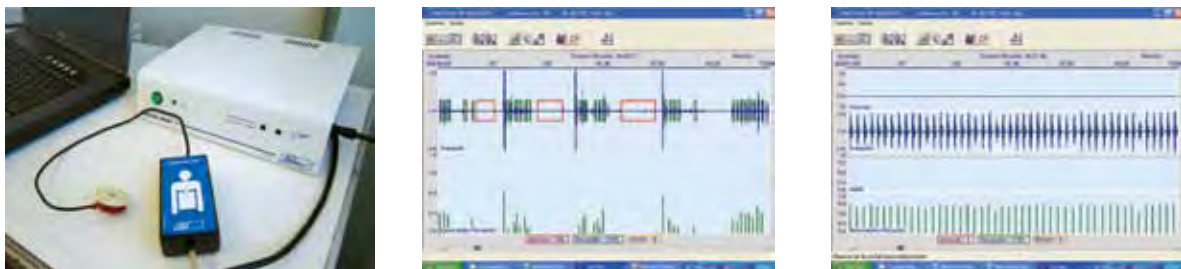
The group's research addresses the design and development of advanced signal processing techniques and the interpretation of biomedical signals to improve monitoring, diagnosis, disease prevention and pathology treatment. We explore new methods and techniques for multi-channel and multimodal acquisition, processing, modelling and interpretation of clinically relevant information from biomedical signals. Our main objective is to improve the non-invasive diagnosis capability through the characterization of physiological phenomena, and to enhance early detection of major diseases.

The specific objectives of the group are the proposal and design of novel signal processing algorithms and the development of a new biosignal databases developed jointly with hospitals to assess and validate the performance of the developed algorithms. To validate the clinical information of some new surface signals, we developed specific invasive/non-invasive protocols with the collaboration of our hospital partners. Currently, we are also studying the proposed algorithms in animal models to test performance in studies with well-controlled physiological conditions.

The group focuses its research in a translational way to promote that scientific and technology contributions can be transferred. Currently, our scientific prototypes are used in the hospitals for research purpose and for industrial developments.

Highlights in 2011:

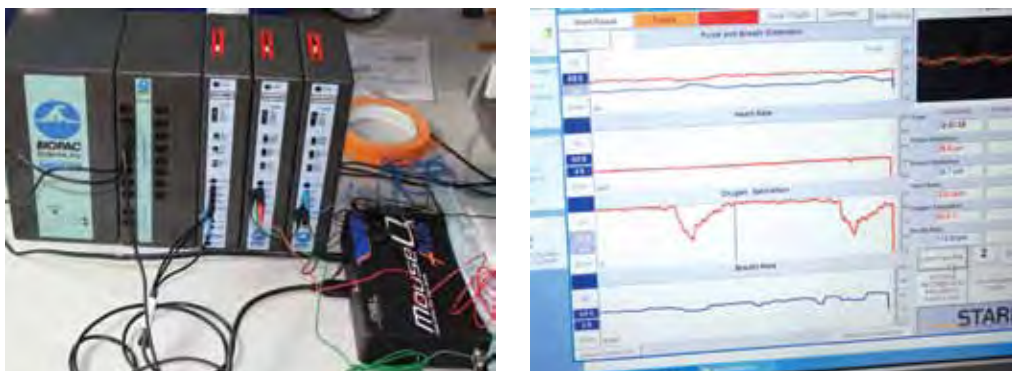
- We have proposed a new method for classifying snoring subjects according to their Sleep Apnea Hypopnea Syndrome (SAHS) severity and an original definition of regular and non-regular snores, as a novel powerful tool for screening SAHS severity, in collaboration with the Hospital Germans Trias i Pujol, Badalona.
- We have evaluated different methods to estimate the upper airway respiratory resistance, in collaboration with the Institute of Biomedical Engineering (Karlsruhe), the Klinikum Bethanien and the company MCC-Med, Germany.



Respiratory sound detection and interpretation in a novel single channel portable device for snore-based screening of Sleep Apnea-Hypopnea Syndrome (SAHS).

- We developed a method to study the respiratory flow cycle morphology in Chronic Heart Failure and the respiratory pattern in critical patients with mechanical ventilation, in collaboration with the University of Lund, Sweden, and the Hospital de Sant Pau, Barcelona.
- We proposed a new method to assess the respiratory muscle efficiency in patients with Chronic Obstructive Pulmonary Disease, in collaboration with the Hospital Germans Trias i Pujol and the Hospital del Mar, Barcelona.
- We designed a multimodal protocol for a rat model of SAHS in collaboration with the Biophysics and Bioengineering Unit of the School of Medicine, University of Barcelona.

Multimodal biosignal interpretation in a SAHS rat model.



Research projects

■ **BIOMIND** Multimodal biomedical data interpretation in sleep and neurological disorders, obstructive pulmonary diseases, cardiac pathologies and cardiorespiratory interactions (2011-2013).

PI: **Raimon Jané**
MICINN.

■ **M3PBIO** Multichannel Monitoring and Multimodal Processing of Biomedical Signals in Sleep-Disordered Breathing, Respiratory Diseases and Cardiac Pathologies (2007-2011).

PI: **Raimon Jané** (managed by UPC)
MICINN.

■ Grup de recerca consolidat (2009-2013).

PI: **Raimon Jané**
Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (SGR 2009).

■ Real time analyzer of respiratory sounds for detection and evaluation of snoring and apnoea (2009-2011).

PI: **Raimon Jané** (managed by UPC)
Industrial project with SIBEL, S.A.

Publications

■ Fiz, J. A., Solà, J. and Jané, R. (2011). Métodos de análisis del ronquido. *Medicina Clínica*, 137 (1), 36-42

■ Morgenstern, R., Morgenstern, C., Jane, R. and Lee, S. H. (2011). Usefulness of an expandable interbody spacer for the treatment of foraminal stenosis in extremely collapsed disks preliminary clinical experience with endoscopic posterolateral transforaminal approach. *Journal of Spinal Disorders & Techniques*, 24 (8), 485-491

■ Arcentales, A., Giraldo, B. F., Caminal, P., Benito, S. and Voss, A. (2011). Recurrence quantification analysis of heart rate variability and respiratory flow series in patients on weaning trials. In *Conf Proc IEEE Eng Med Biol Soc. 2011*, 2724-7

■ Chaparro, J. A., Giraldo, B. F., Caminal, P. and Benito, S. (2011). Analysis of the respiratory pattern variability of patients in weaning process using autoregressive modeling techniques. In *Conf Proc IEEE Eng Med Biol Soc. 2011*, 5690-3

■ Garde, A., Giraldo, B. F., Sornmo, L. and Jane, R. (2011). Analysis of the respiratory flow cycle morphology in chronic heart failure patients applying principal components analysis. In *Conf Proc IEEE Eng Med Biol Soc. 2011*, 1725-8

■ Jane, R., Fiz, J. A., Sola-Soler, J., Mesquita, J. and Morera, J. (2011). Snoring analysis for the screening of sleep apnea hypopnea syndrome with a single-channel device developed using polysomnographic and snoring databases. In *Conf Proc IEEE Eng Med Biol Soc. 2011*, 8331-3

■ Mesquita, J., Fiz, J. A., Sola-Soler, J., Morera, J. and Jane, R. (2011). Normal non-regular snores as a tool for screening SAHS severity. In *Conf Proc IEEE Eng Med Biol Soc. 2011*, 3197-200

■ Morgenstern, C., Schwaibold, M., Randerath, W., Bolz, A. and Jane, R. Comparison of upper airway respiratory resistance measurements with the esophageal pressure/airflow relationship during sleep. In *Conf Proc IEEE Eng Med Biol Soc. 2011*, 3205-8

■ Sarlabous, L., Torres, A., Fiz, J. A., Gea, J., Martinez-Llorens, J. M., Morera, J. and Jane, R. Evaluation of the respiratory muscles efficiency during an incremental flow respiratory test. In *Conf Proc IEEE Eng Med Biol Soc. 2011*, 3820-3

■ Sola-Soler, J., Fiz, J. A., Morera, J. and Jane, R. Bayes classification of snoring subjects with and without Sleep Apnea Hypopnea Syndrome, using a Kernel method. In *Conf Proc IEEE Eng Med Biol Soc. 2011*, 6071-4

Collaborations with other research centres

Prof. Dr. Antonio Bayes Genis Grup ICREC, Servei Cardiologia Hospital Universitari Germans Trias i Pujol, Badalona (Spain).

Dr. Salvador Benito Medicina Intensiva, Hospital de la Santa Creu i Sant Pau, Barcelona (Spain).

Prof. Dr. Konrad Bloch Pulmonary Division at University of Zurich (Switzerland).

Prof. Dr. Armin Bolz Institute of Biomedical Engineering, University of Karlsruhe (Germany).

Prof. Dr. Manuel Doblaré Grupo de Mecánica Estructural y Modelado de Materiales, Universidad de Zaragoza (Spain).

Prof. Dr. Ramon Farré CIBERES / IDIBAPS, Unitat de Biofísica i Bioenginyeria, Facultat de Medicina, Barcelona (Spain).

Prof. Dr. Alejandro Frangi Grupo de Imagen Computacional y tecnologías de Simulación en Biomedicina (CISTIB), Universidad Pompeu Fabra (Spain).

Dr. Joaquim Gea CIBERES, Servei Pneumologia, Hospital del Mar-IMIM, Barcelona (Spain).

Dr. Alfredo Hernández Laboratoire Traitement du Signal et de l'Image, Université de Rennes 1, Institut National de la Santé et de la Recherche Médicale, INSERM (France).

Dr. Eric Laciár Dept. Electrónica y Automática, Universidad Nacional de San Juan (Argentina).

Prof. Dr. Pablo Laguna Instituto de Investigación de Aragón (I3A), Universidad de Zaragoza (Spain).

Dr. Josep Morera CIBERES, Servei de Pneumologia, Hospital Germans Trias i Pujol, Badalona (Spain).

Prof. Dr. Javier Pavía Grupo de Imagen Médica (GIB), Universidad de Barcelona (Spain).

Prof. Dr. Thomas Penzel Interdisciplinary Sleep Center. Charité University Hospital, Berlin (Germany).

Prof. Dr. Winfried J. Randerath Institut for Pneumologie, Klinik Bethanien, Solingen (Germany).

Prof. Dr. Domènec Ros Grupo de Imagen Médica (GIB), Universidad de Barcelona (Spain).

Prof. Dr. Andrés Santos Grupo de Tecnologías de Imágenes Médicas (BIT). Universidad Politécnica de Madrid (Spain).

Dr. Matthias Schwaibold MCC-Med GmbH & Co. KG, Karlsruhe (Germany).

Prof. Dr. Lotfi Senhadji Laboratoire Traitement du Signal et de l'Image (LTSI), Université de Rennes 1, Institut National de la Santé et de la Recherche Médicale, INSERM (France).

Dr. Marta Sitges IDIBAPS, Servei de Cardiologia, Hospital Clínic de Barcelona (Spain).

Prof. Dr. Leif Sörnmo Signal processing group, Lund University (Sweden).

Prof. Dr. Jaume Veciana Grupo de Nanociencia Molecular y Materiales Orgánicos del Instituto de Ciencia de Materiales de Barcelona (NANOMOL-CSIC), Barcelona (Spain).

Prof. Dr. Andreas Voss University of Applied Sciences, Jena (Germany).

Dr. James J. Yue Yale Orthopaedics and Rehabilitation, School of Medicine, Yale University (USA).

Scientific equipment and techniques

- BIOPAC system for multichannel cardiac, respiratory, neural and muscular biomedical signal acquisition
- Non-invasive Vital Signs Monitor for small lab animals (mice and rats) (Mouse-Ox Plus)
- Databases of biomedical signals from Hospitals and Animal Laboratories
- Snoring analyzer equipment (SNORYZER)
- Sensors, electrodes and microphones to obtain cardiac, respiratory, neural, muscular and sleep biomedical signals
- Polisomnographic equipments available in the Sleep Laboratory of collaborator Hospitals
- Beat to beat arterial blood pressure and haemodynamic monitor equipment (FINOMETER)
- Research laboratory with full equipment for acquisition and processing of Biomedical Signal to test new sensors and to define clinical protocols (preliminary tests and control subjects).
- Computing server for high performance biomedical signals

Artificial Olfaction

Group leader: Dr. Santiago Marco

Senior researcher: Dr. Agustín Gutiérrez

Postdoctoral researcher: Dr. Jordi Fonollosa

PhD students: Ariadna Bartra, Lluís Fernández, Ana Verónica Guamán, Sergio Oller, Marta Padilla, Erola Pairó, Víctor Pomareda, Francisco Miguel Tarzán

Technicians: Idoya Agudo, Didier Domínguez, Miguel Lechón, Pablo Meca, Sergi Udina

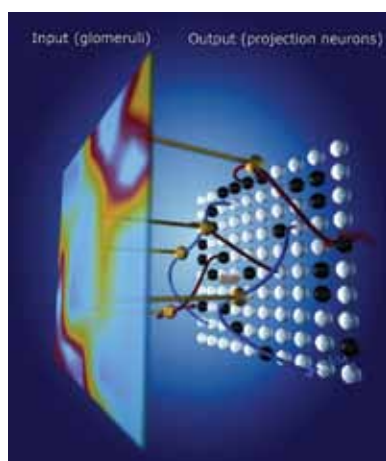
Visitors: Bernd Friedl, Lucas Georges, Zeev Karpas, Masoumeh Mohammadnejad, Davide Polese



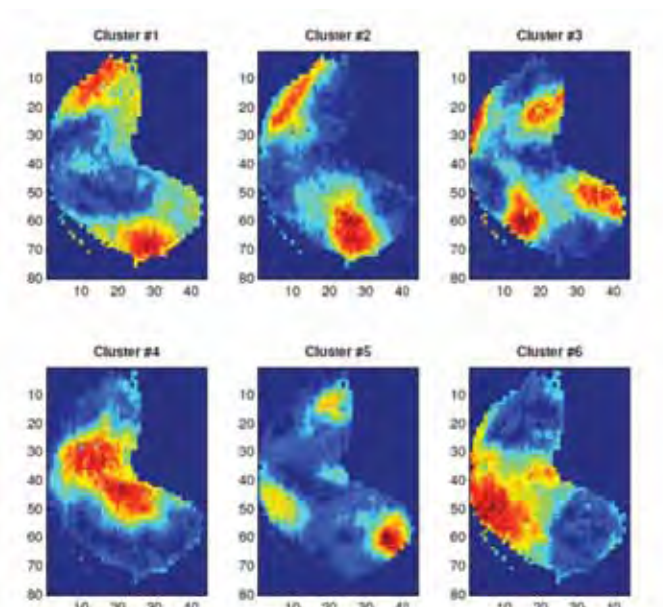
Artificial olfaction (AO) systems are intelligent chemical instruments for the detection of volatile compounds and smells. These systems usually combine an array of nonspecific chemical sensors with a pattern recognition system. The emphasis is not on the identification and quantification of the individual components – as is the case with analytical instruments – but rather on the overall evaluation of the odour. Moreover, AO systems tend to favour miniaturised devices capable of analyzing an odour in seconds. The focus of our research in this field is the development of signal and data processing systems inspired by the neuronal processing of the biological olfactory pathway.

Our research in 2011 included the following:

- Within the framework of the European NEUROCHEM project for the development of biologically-inspired computational solutions, we have developed detailed neuronal models of insect mushroom bodies and integrated more abstract complete models inspired by the olfactory system of vertebrates in a neural simulator. These models have been integrated in an autonomous robot for odour navigation in real-time. The system is able to locate a chemical source in mixed plume conditions.
- Toxic leakages from industry can be a major environmental health problem. Using a set of vehicles equipped with chemical sensors in the polluted area and proper data fusion algorithms, it is possible to uncover the chemical source. We have developed a Bayesian chemical source localization algorithm using concentration information that is robust against time-varying backgrounds.
- Sepsis is a major cause of death in intensive care units. In an exploratory cooperation with Daniel Navajas' group at IBEC (page 33), we have shown that breath analysis with ion mobility spectrometry can detect sepsis in rats with minimum analysis times and without any sample pre-treatment.
- While immunosensors can be very selective, they still show cross-sensitivities to structurally related compounds. In cooperation with the Applied Molecular Receptor Group at IQAC, led by Prof. M.P. Marco, we have shown that pattern recognition techniques applied to an Immunosensor array can improve the selectivity towards similar anabolic steroids found in doping cases or illegal feeding.
- Wine fraud in Europe can reach 5% in some countries. In conjunction with the University of Córdoba's Department of Analytical Chemistry, we have shown that ion mobility spectrometry together with pattern recognition techniques can be used to identify the Certified Brand of Origin of white wines.



Models of the insect antennal lobe developed in collaboration with Dr. Dominique Martinez, (INRIA).



Clusters of activity in the olfactory bulb in response to odorants recovered by non-negative matrix factorization (original data courtesy of Leon-Johnson Lab, UCI).

Research projects

- **NEUROCHEM** Biologically Inspired Computation for Chemical Sensing (2008-2011).
PI: **Santiago Marco** (coordinator; managed by UB)
Collaborative project (ICT) within the framework of EU-FP7.
- **LOTUS** Localisation of Threat Substances in Urban Society (2009-2011).
PI: **Santiago Marco** (managed by UB)
Collaborative project within the framework of EU-FP7.
- **BREATH** Exhaled breath inflammatory, oxidative stress and metabonomic biomarkers in chronic obstructive pulmonary disease and lung cancer (2009-2011).
PI: **Santiago Marco**
MICINN, Instituto de Salud Carlos III.
- **PROSAVE²** Proyecto de Investigación en Sistemas Avanzados para un avión más Eco-Eficiente (2010-2011).
PI: **Santiago Marco**
MICINN, Consorcios Estratégicos Nacionales en Investigación Técnica (CENIT).
- **SEDUCE** Systems for the Detection of Explosives in Centers and Public Infrastructures (2008-2011).
PI: **Santiago Marco** (managed by UB)
MICINN, Consorcios Estratégicos Nacionales en Investigación Técnica (CENIT).

- Prototipatge d'instrument de mesura de consum energètic - gas natural (2009-2011).

PI: **Santiago Marco**
Centre d'Innovació i Desenvolupament Empresarial (CIDEM).

- **SOMNO-ALERT® P-10** Detección de Somnolencia (2009-2011)

PI: **Santiago Marco**
Industrial project with FICOMIRRORS, S.A.

- Intelligent signal processing for sensor systems in bioengineering (2009-SGR-753).

PI: **Santiago Marco**
Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR). Convocatòria d'ajuts per donar suport a les activitats dels grups de recerca de Catalunya (2009-2013).

- Signal processing optimized for the detection of explosive and toxic substances.

PI: **Santiago Marco**
(2009-FI-VP051626).

- Olfactory bulb image analysis and its implications in odour coding.

PI: **Santiago Marco**
(FPSC-IBEC).

Publications

- Calvo, D., Tort, N., Pablo Salvador, J., Marco, M. P., Centi, F. and Marco, S. (2011). Preliminary study for simultaneous detection and quantification of androgenic anabolic steroids using ELISA and pattern recognition techniques. *Analyst*, 136, 4045-4052
- Garrido-Delgado, R., Arce, L., Guaman, A. V., Pardo, A., Marco, S. and Valcárcel, M. (2011). Direct coupling of a gas-liquid separator to an Ion Mobility Spectrometer for the classification of different white wines using chemometrics tools. *Talanta*, 84 (2), 471-479
- Auffarth, B., Gutierrez-Galvez, A. and Marco, S. (2011). Continuous spatial representations in the olfactory bulb may reflect perceptual categories. *Frontiers in Systems Neuroscience*, 5 (82), 1-8
- Auffarth, B., Gutierrez, A. and Marco, S. (2011). Statistical analysis of coding for molecular properties in the olfactory bulb. *Frontiers in Systems Neuroscience*, 5 (62), 1-8
- Fernandez, L., Gutierrez-Galvez, A., Fonollosa, J. and Marco, S. (2011). A biomimetic gas sensor array system designed to test computational olfaction models. *20th Congress of European Chemoreception Research Organization (ECRO-2010)*, Avignon, France
- Gutierrez-Galvez, A., Fernandez, L. and Marco, S. (2011). Study of sensory diversity and redundancy to encode for chemical mixtures. *AIP Conference Proceedings*, New York City, USA
- Marco, S. (2011). Signal processing for chemical sensing: Statistics or biological inspiration. *AIP Conference Proceedings*, New York City, USA
- Pairo, E., Maynou, J., Vallverdu, M., Caminal, P., Marco, S. and Perera, A. (2011). MEET: Motif elements estimation toolkit. *Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE*, Boston, USA
- Pomareda, V. and Marco, S. (2011). Chemical plume source localization with multiple mobile sensors using bayesian inference under background signals. *AIP Conference Proceedings*, New York City, USA
- Ziyatdinov, A., Calvo, J. M. B., Lechon, M., Bermudez i Badia, S., Verschure, P. F. M. J., Marco, S. and Perera, A. (2011). Odour mapping under strong backgrounds with a metal oxide sensor array. *AIP Conference Proceedings*, New York City, USA

■ Ziyatdinov, A., Fernandez-Diaz, E., Chaudry, A., Marco, S., Persaud, K. and Perera, A. (2011). A large scale virtual gas sensor array. *AIP Conference Proceedings*, New York City, USA

Collaborations with other research centres

Leon and Johnson Group Dept. of Neuroscience, University of California, Irvine (USA).

Prof. Dr. Josep Roca Dept. Ciències Clíiques, UB-Hospital Clínic de Barcelona (Spain).

Prof. Marta Cascante Dept. Bioquímica I Biologia Molecular, Universitat de Barcelona (Spain).

Prof. Paul Verschure Cognitive, Perceptive and Emotive Systems, Universitat Pompeu Fabra, Barcelona (Spain).

Prof. Anders Lansner The Brain Institute, Stockholm (Sweden).

Prof. Krishna Persaud Chemoreception Group, University of Manchester (UK).

Dr. D. Martínez Cortex Group, LORIA, Nancy (France).

Prof. Pere Caminal CREB, Technical University of Catalonia, Barcelona (Spain).

Prof. J.P. Rospars Insect Physiology Unit, Institut National de la Recherche Agronomique, Versailles (France).

Dr. Tim Pearce Neurolab, Dept. Engineering, University of Leicester (UK).

Dr. Lourdes Arce Dept. Química Analítica, Universidad de Córdoba (Spain).

Prof. Enrique Ruspini European Center for Softcomputing, Mieres, Asturias (Spain).

Prof. María Pilar Marco Applied Molecular Receptor group (AMRg), Institute of Advanced Chemistry of Catalonia, Spanish Council for Scientific Research (IQAC-CSIC), Barcelona (Spain).

Dr. Matteo Falasconi Sensor Laboratory, University of Brescia (Italy).

Scientific equipment and techniques

- Infrared Camera (FLIR Systems A40M)
- NST 3320 Electronic Nose
- Dycometal Climate-controlled Chamber adapted for atmosphere modification
- Computer equipment and general purpose electronic instrumentation
- Gas chromatograph/mass spectrometer (THERMOSCIENTIFIC)
- Gas sensor test station, with associated equipment for excitation, data logging and mixture generation
- Ion mobility spectrometer (Gas Detector Array by AirSense Analytics)
- Computing cluster with 32 processors
- Automated headspace sampler (Agilent)
- Temperature and humidity gas conditioner (Assay Technologies)
- Photolionization detector
- Double-column gas chromatography system with flame ionization detector (HP)
- Olfactive port for gas chromatography
- UV-IMS (ultraviolet-ion mobility spectrometry)
- Owlstone vapor generator
- Infusion pumps K-systems



Robotics

Prof. Dr. Alícia Casals

Robotics and biomedical
engineering programme

Robotics

Group leader: Prof. Dr. Àlícia Casals

Senior researchers: Joan Aranda, Manel Frigola

PhD students: Luis Ernesto Amigo, Eduard Bergés, Miquel Casamitjana, Xavier Giralt, Albert Hernansanz, Vijaykumar Rajasekaran

Masters students: Federica Calcagno, Ludovico Donegani, Emma Federici, Paloma Fuentes, Aaron Montero, Velia Napoli, Lluís Sala

Technician: Manuel Vinagre



Research on robotics in medicine deals with the close interaction between people and robots. IBEC's Robotics group, together with the associated group of CREB–UPC, designs and develops intelligent robotic systems to assist people with disabilities and medical personnel. This involves acquiring detailed knowledge about the behaviour and intentions of users, not only to develop an interface adapted to both their needs and the requirements of the tasks, but also to facilitate fine tuning of the level of cooperation between the user and the machine, taking into account the user's abilities.

Our main project in rehabilitation is the design and development of robot control strategies for a simultaneous operation of a neurorobot and a motor neuroprosthesis. The project intends to advance in the “assist-as-needed” concept; that is, based on the use of biofeedback, an orthotic device (an exoskeleton) is controlled from user's volitional commands, considering also the user's capabilities (fatigue, level of motor disorder, etc) and their dynamic changes. A special effort is dedicated to developing adequate compliant control strategies, which ensure safe interaction during physical contact between human and robot.

In surgical robotics our research is focused on the design of assisted teleoperation strategies, with the goal of reducing stress for surgeons who perform operations requiring highly delicate actions and great precision. Some surgical procedures can be carried out safely and more effectively with robotic assistance, and this technique also improves reliability. The research of the group does not uniquely focus on the research to improve ergonomics, efficiency and safety during a robot assisted intervention, but also on the transfer of this technology for its clinical applicability. At present, the research team is working in an FP7 Coordinated Action, Eurosurge, which aims to study the technical, ethic and legal aspects that limit the commercial expansion of surgical robots.



Study of control strategies in neurorobotics.



Experimental surgical robot platform for laparoscopic surgery (with CREB-UPC).

Research projects

■ Eurosurge European Robotic Surgery

PI: **Alicia Casals**

Coordination Action FP7-ICT-2011-7.

■ HYPER Hybrid NeuroProsthetic and NeuroRobotic Devices for Functional Compensation and Rehabilitation of Motor Disorders (2009-2014).

PI: **Alicia Casals**

MICINN, Actividad Investigadora CONSOLIDER – INGENIO 2010.

■ Estudio y desarrollo de estrategias de cooperación multirobot con arquitecturas redundantes (2009-2010).

PI: **Alicia Casals** (managed by UPC)

MICINN, Comisión Interministerial de Ciencia y Tecnología (CICYT).

■ Amat, J. (2011). Design of a 3-DoF joint system with dynamic servo-adaptation in orthotic applications. *2011 IEEE International Conference on Robotics and Automation (ICRA)*, Shanghai, China

■ Vaca, R., Aranda, J., Amat, J. and Casals, A. (2011). Safe human-robot co-manipulation in assisted robotic surgery. *Computer Assisted Radiology and Surgery (CARS)*, Berlin, Germany

Collaborations with other research centres

Dr. Josep M. Tormos Fundació Institut Guttmann, Barcelona (Spain).

Dr. Ángel Gil Hospital de Tetraplégicos de Toledo (Spain).

Dr. Enric Laporte Corporació Sanitària Parc Taulí, Sabadell (Spain).

Dr. Joan Antoni Hueto Hospital de la Vall d'Hebrón, Barcelona (Spain).

Dr. Carlos Torrens Hospital del Mar, Barcelona (Spain).

Dr. Javier Magriñá Mayo Clinic, Scottsdale, Arizona (USA).

Salvador Riera Centre per a la Vida Independent, Barcelona (Spain).

Publications

■ Miguel Munoz, L., Casals, A., Frigola, M. and Amat, J. (2011). Motor-model-based dynamic scaling in human-computer interfaces. *IEEE Transactions on Systems Man and Cybernetics Part B-Cybernetics*, 41 (2), 435-447

■ Garcia, N., Sabater-Navarro, J. M., Gugliemeli, E. and Casals, A. (2011). Trends in rehabilitation robotics. *Medical & Biological Engineering & Computing*, 49 (10), 1089-1091

Scientific equipment and techniques

- Experimental robotized domestic environment consisting of a robot, video cameras, video projector, scan laser and PC for robot and environment intelligent control
- KUKA lightweight robot. Robot specially designed for safe interaction with humans and its environment. It is equipped with a control software environment developed by the research team to program anatomic constraints in order to operate in virtual environments
- Computer controlled LEDs based lighting system for the operating room
- A BCI working platform based on an Emotiv Epoc headset (EEG acquisition system)
- 2 PC with multiprocessor architecture. Tesla C2050
- Ultrasound probe: B-Ultrasonic Diagnostic Equipment Model WED-2000
- 6D magnetic positioning sensors (Polhemus)
- A 50" 3D monitor
- Basic electronics laboratory equipment





Networking

Partnerships

ICREA

The Catalan Institution for Research and Advanced Studies (ICREA) is a foundation supported by the Catalan Government. Its aim is to recruit top scientists for the Catalan R&D system to lead new research groups, strengthen existing ones and set up new lines of research. To achieve its objectives, the foundation works closely with Catalan universities and research centres through long-term agreements that allow ICREA researchers to participate in research groups in these centres. In 2011, four of IBEC's 15 group leaders were ICREA research professors.

Fundación Botín

IBEC's collaboration with the Fundación Botín, a Spanish private institution, is in regard to the technology transfer of results obtained by the Nanobioengineering group led by associate director Josep Samitier (page 42).

CRESIB

IBEC and the Centre de Recerca en Salut Internacional de Barcelona (CRESIB) have an official agreement, signed in 2010, in order to facilitate collaboration in certain areas of common interest. This proposed the establishment of a mixed unit of personnel from both institutes aimed at developing diagnostic and therapeutic nanomedicine-based systems to be applied to malaria.

Consequently, Dr. Xavier Fernández-Busquets, senior researcher in IBEC's Nanobioengineering group, is undertaking research into targeted nanovectors for antimalarial drug delivery across the two institutes and with support from both. In 2011 this initiative was favourably reviewed and will continue for another three years.

CIBER-BBN

Founded in 2006, the Biomedical Research Networking Center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN) is one of Spain's Biomedical Research Networking Centers (CIBERs). The primary aim of these consortia is to create large multidisciplinary and multi-institutional networks of research centres that will integrate basic and clinical research. CIBER-BBN, which is financed by the Instituto de Salud Carlos III, works in a number of areas including bioengineering, biomedical imaging, biomaterials, tissue engineering and nanomedicine. Research is focused on disease prevention, diagnostics systems and technologies for specific therapies, such as regenerative medicine and nanotherapies. IBEC works closely with CIBER-BBN, playing a role in the organisation and taking part in its research groups to help them carry out their work. The two institutions also share technical research equipment.

CIBER-BBN projects (2010-2011)

■ **ES-CELLTHERAPY** Use of human pluripotent stem cells as vehicles for localized delivery of therapy to brain tumors.

PI: **Ángel Raya; Josep Planell**

■ **NACRE** New Approaches for Cartilage Regeneration.

PI: **Ángel Raya**

■ **NANOXEN** Use of optical molecular nanoswitches to control nervous functions in *Xenopus tropicalis*.

PI: **Fausto Sanz** (under UB); **María García-Parajo**

■ **NANOMEDIAG** Nanobioanalytical platforms for improved medical diagnosis of infections caused by pathogen microorganisms.

PI: **Josep Samitier**

■ **CELL MECHANICS** Understanding mechanotransduction and cell-substrate interaction mechanisms. Applications in cell therapy and tissue engineering.

PI: **Josep Samitier; Josep Planell; Daniel Navajas**

While most of IBEC's funds come from the Generalitat de Catalunya, the University of Barcelona and the Technical University of Catalonia, an increasing proportion comes from national and international competitive research funding, ranging from large instruments such as the EU's Framework Programmes to independent or national foundations. Both projects and people are funded, with IBEC proud to be able to claim no fewer than four group leaders with their own support from one of the most prestigious sources, ICREA, in 2011.

■ **OLIGOCODES** Universal Diagnostic Platforms Based On Oligonucleotide Codified Nanoparticles and DNA Microarray Sensor Devices.

PI: **Josep Samitier**

■ **BIO-SCAFF** Desarrollo de nuevos conceptos de andamiajes y cultivos celulares para medicina regenerativa.

PI: **Àngel Raya**

■ **BIOSCAFF-EYE** Bio-engineered stem cell niches (BioSC-niche) in ocular surface reconstruction for corneal blindness: from basic research to clinical trials.

PI: **Josep Samitier; Josep Planell**

■ **Bioproterial** Biological activity of matrix proteins at the cell-material interface.

PI: **Josep Planell; George Altankov**

■ **BIOGELANGIO** Biomimetic extracellular matrices for angiogenic activation and anti-inflammatory activity in regenerative medicine.

PI: **Josep Planell**

■ **SCAFFTIDE** 3D scaffolds and implants functionalized and reinforced with recombinant protein polymers for regenerative medicine.

PI: **Josep Planell**

■ **INDI-MUSICA** Indexes obtained from computational models and multiscale-multimodal biomedical signals for the diagnosis of cardiac pathologies.

PI: **Raimon Jané**

■ **MUDIRES** Multimodal Diagnosis by Interpretation of Multiscale Signals in the Respiratory System.

PI: **Raimon Jané**

■ Investigación en Señales y Sistemas Biomédicos.

PI: **Raimon Jané**

■ **VPHTk** Virtual Physiological Human Toolkit.

IP: **Raimon Jané**

CIBERNED

Also one of Spain's Biomedical Research Networking Centers (CIBERs), CIBERNED is composed of 63 research groups working on basic and clinical research into neurodegenerative diseases. Two IBEC groups are involved in CIBERNED projects, which are also financed by the Instituto de Salud Carlos III.

■ **BESAD-P** Biomarkers of Early Stages of Alzheimer Disease-Prevention (2010-2012).

PI: **Jose Antonio del Río**

■ Red española de investigación en enfermedades neurológicas PRY-114 (2009-2012).

PI: **Jose Antonio del Río**

■ Generación de un modelo neuronal dopaminérgico a partir de células madre pluripotentes inducidas de pacientes con enfermedad de Parkinson asociada a mutaciones en el gen LRRK2 (2010-2011).

PI: **Àngel Raya**

Research agreements and MoUs

Groups from the UB and the UPC Associated with IBEC

In 2011, the IBEC continued to collaborate with the University of Barcelona (UB) and the Polytechnic University of Catalonia (UPC) on joint research programmes. Under an agreement signed in 2006, IBEC funds ten PhD scholarships a year, one for each associated group:

- Biomaterials, Biomechanics and Tissue Engineering (UPC)
- Biomedical Signals and Systems Unit (UPC)
- Robotics and Vision Unit (UPC)
- Instrumentation and Bioengineering Unit (UPC)
- Ionizing Radiation Dosimetry Unit (UPC)
- Graphical Computer Science Unit (UPC)
- Bioelectronics Unit (UB)
- Biophysics and Bioengineering Unit (UB)
- Microbiology Unit (UB)
- Surface Science and Nanotechnology Unit (UB)

Memoranda of Understanding

IBEC's MoUs with outside organisations numbered five in 2011, with more in the pipeline.

■ Fundació Clínic - Hospital Clínic

IBEC works with both the Fundació Clínic and the Hospital Clínic in Barcelona to promote applied research across all three institutions.

■ The Bellvitge Institute for Biomedical Research (IDIBELL), Barcelona

On 6 June 2011, IBEC presented its activities to biomedical researchers and clinicians from IDIBELL to kick off the official collaboration agreement between the two institutes, which was signed in September 2009. The presentation featured talks on IBEC's new Strategic Research Initiatives (SRIs) – the institute's 'flagships' of interdisciplinary research focusing on providing solutions for specific pathologies or bottlenecks and involving several IBEC groups – in nanomedicine, cell engineering and intelligent healthcare.

The next step would be a series of focused workshops alongside two or three groups from IDIBELL who have identified 'collaborative potential' in some of the expertise displayed by their counterparts at IBEC, and vice-versa.

The close interaction of researchers at IBEC and medical staff at IDIBELL will enable clinicians to benefit from the technology being developed at IBEC and allow investigators here to gain access to clinical opinion. With the official kick-off of the activities of this Memorandum

IBEC constantly pursues opportunities to collaborate on a long-term basis with other world-class national or international research institutes with an agreement or Memorandum of Understanding (MoU), with particular emphasis on clinical translation. Such agreements aim to promote exchange of researchers to execute projects, the dissemination of information, sharing of resources and organization of joint activities, and the implementation of cooperative research between them.

of Understanding, IBEC will be able to ensure that its research in the three focused areas of nanomedicine, cell engineering and intelligent healthcare develops in directions that will have the most impact on health and society.

■ **National Institute for Materials Science (NIMS), Japan**

The MoU between the National Institute for Materials Science (NIMS) in Tsukuba, Japan, and IBEC has been in place since July 2009 and focuses on collaborations on the design of biomaterials surfaces and biosensors for cell function, manipulation and analysis.

■ **Institute of Tissue Regeneration Engineering (ITREN), Dankook University, Korea**

Honouring the agreement to exchange researchers in the MoU signed with Korea's Institute of Tissue Regeneration Engineering (ITREN) in 2008, senior researcher Dr. Oscar Castaño from the Bio/Non-Bio Interactions for Regenerative Medicine group spent three months at ITREN in 2011 working on hybrid bioactive nanofibers for bone regeneration with the institute's Bioadvanced Materials group. Reciprocally, ITREN PhD student Jong-Eun Won spent three months with the IBEC group from February to April.

■ **University of Warwick, UK**

In 2011 IBEC played host to visitors from the University of Warwick's Centre for Cognitive and Neural Systems (see page 92), following the signing of a Memorandum of Understanding between the two institutes in 2010.

■ A collaborative research agreement between IBEC and the **Interstaatliche Hochschule für Technik Buchs (NTB)** is planned to be renewed in 2012. Stemming from a long-term informal collaboration between IBEC's Nanobioengineering lab (page 42) and the Switzerland-based institute, the relationship was formalised in 2009 and promotes a cooperative approach to the development of new nanotechnology-based methods for the fabrication of sensor arrays and microfluidic structures for lab-on-chip devices.

■ In October 2011, a delegation of the Innovation department of the **Vall d'Hebron Research Institute (VHIR)** in Barcelona visited IBEC to establish the basis of a cooperation agreement similar to the one signed with other hospitals.

Institutional initiatives and projects

Spanish Nanomedicine Platform

The Spanish Nanomedicine Platform (NanoMed Spain) is a forum managed by IBEC that brings together public research centres, hospitals, companies and government representatives to unite public and private interests in the development of common strategies. NanoMed Spain represents the interests of its stakeholders in the burgeoning and multidisciplinary area of nanomedicine, and is supported by the Spanish Ministry of Science and Innovation (MICINN).

In 2011, the activity of NanoMed Spain was focused on:

- Contributing to define the Spanish position in relation to HORIZON 2020, the continuation of the European Commission's Seventh Framework Programme (FP7), in all aspects related to the application of nanotechnology to healthcare.
- Collaboration with other sectors which can benefit from the application of nanotechnology to healthcare, such as the food and environment industries. Beyond collaboration with other technological platforms representing these sectors, IBEC associate director and coordinator of NanoMed Spain Josep Samitier was appointed the Spanish representative at the European Food Safety Authority (EFSA) Scientific Committee to deliver some practical guidelines for the risk assessment of engineered nanomaterial (ENM) applications in food and feed. This is the first of its kind to give practical guidance for addressing potential risks arising from applications of nanoscience and nanotechnologies in the food and feed chain.
- Presentation of the document "Nanomedicine in Spain 06-10", which provides an overview of the main initiatives, large multidisciplinary projects and internationalization efforts undertaken under NanoMed Spain's advice and leadership.
- Participation in the validation workshop, 'Nanomedicine in Spain: present and future', held at the Center for Industrial Technological Development (CDTI) in Madrid on 1 February 2011. Experts from diverse Working Groups in diagnostics, nanopharmaceuticals and regenerative medicine discussed the conclusions that could be drawn from the mapping of R+D capacities and industry expectations in these areas, and outlined

possible next steps for innovation in nanomedicine in the country. NanoMed Spain is currently working to distill the results into a document to advise policy making and national investors to help the clinical transfer of nanomedicine become a reality.

PRINCIPAL ACTIVITIES of NANOMED SPAIN:

Collaboration with other platforms

NanoMed Spain was the organiser, together with the Spanish Technology Platform for Innovative Medicines and the Platform on Healthcare Technology, of the 4th Annual Conference of Technological Platforms for Biomedical Research, which took place in Madrid on 28 February-1 March 2011. This annual event has become a key date in the nanotechnology calendar and showcases how the field is aiding the development of innovative products in medical technologies and the pharmaceutical industry. It also provides an excellent meeting point for the private and public sectors, as well as policy makers.

Representation of the Spanish nanomedicine community at international level

In October 2011, the annual forum of the European Platform on Nanomedicine (ETPN) was hosted in Barcelona by IBEC in its capacity as manager of NanoMed Spain and coordinator of the Connect-EU Nanobio+Nanomed working group (see opposite). The Spanish Secretary of Innovation and Catalonia's General Secretary of Universities and Research opened the conference, which welcomed speakers and attendees from the nanomedicine community throughout Europe, spanning research, industry, the medical sector and funding bodies. As nanomedicine has been experiencing continued and increased interest, the event focused strongly on raising awareness for translational research and clinical needs, with particular emphasis on discussing strategic opportunities for stakeholders coming from industry, academia and clinics.

NanoMed Spain also participated in EuroNanoForum 2011 in Budapest on 30 May-1 June, at which 1200 attendees learned about recent research breakthroughs and viewed close-to-market nanotechnology developments. Over 70 research centres, industrial leaders such as Bayer, Umicore, Fiat and Nokia, and 15 funding agencies including the European Commission were present at the forum.

In its role as the country's leading research institute in bioengineering and nanomedicine, IBEC manages or is a partner of several national and international initiatives with a range of goals including bringing together entities to network and share resources, providing advice and support, organising events, or acting as a representative, collective voice or expert consultant for stakeholders or funders.

Connect-EU

In 2011 the IBEC-coordinated Connect-EU Nanobio+Nanomed working group, which was set up at the end of 2010, published a 'roadmap' for nanobiotechnology capabilities in Catalonia. The document, 'Connect-EU Nanobio+Nanomed Strategic Research Agenda' was presented on 20 October 2011 at the annual forum of the European Platform on Nanomedicine (ETPN), which followed the 4th IBEC Symposium at the Hospital de Bellvitge on 18-19 October. The document marks the first major step of the working group's first ten months of work, and is the beginning of a series of actions to promote and reinforce Catalan participation in the EU's instruments for research funding such as FP7 and its successor, HORIZON 2020.

As well as providing a plan for this strategic area of knowledge in the region, the publication aims to help define priorities in innovative applications for the pharmaceutical, medtech and environmental industries that can be transformed into European projects.

During 2011, the Connect-EU Nanobio+Nanomed working group developed an agenda of dissemination activities with the aim of establishing itself as a contact with the diverse officers from the research programmes funding nanobio-related activities, such as FP7's NMP, ICT and HEALTH, as well as the Spanish National Contact Points and representatives of the committees working on the annual working programmes. The most important event in this context was the Acte de Presentació dels Grups Connect-EU on 13 July 2011, when all fifteen Connect-EU working groups – which cover areas ranging from aerospace, agribusiness and water to energy, materials and health – were officially presented at the European Commission in Brussels.

KET – Key Enabling Technologies

IBEC's director, Josep A. Planell, is Sherpa of the EC's Key Enabling Technologies High Level Group (HLG) on Nanotechnology. Launched in July 2010, the mission of the HLG is to assess the competitive situation of technologies in the EU, analyse the available public and private R&D capacities for them, and to propose specific policy recommendations for more effective industrial deployment of KETs based on consultations of European stakeholders. The final report will play a vital part in the implementation of the EC's Europe strategy in R+D and innovation, HORIZON 2020.

Strategic alliances

ACER

The Associació Catalana d'Entitats de Recerca (ACER) is an independent association which was established in 2003 to bring together non-profit R&D institutions, as well as helping to define scientific and research priorities and policies in Catalonia. Its ultimate goal is to help consolidate the region as an international leader in scientific and technological research and to optimize the management and implementation of the member centres in the areas they represent, which includes social sciences and humanities, life sciences and health sciences, natural mathematics and technology.

Most of ACER's members have close links with universities and the significant participation of the Generalitat de Catalunya, as well as support from various public and private sources.

Biocat: The BioRegion of Catalonia

Biocat is the organization that coordinates, develops and promotes the biotechnology, biomedicine and medical technology sectors in Catalonia. Its mission is to make the region an international reference in terms of high quality research, competitive networks and an increasingly dynamic knowledge transfer system. IBEC contributes to the BioRegion programme by taking part in the BioRegió Forum, an advisory body actively involved with all the organizations associated with Biocat. IBEC has played an active role in the initiative by creating a medical technology cluster in Catalonia, which is run by Biocat.

BioNanoMed Catalunya

In May 2011, the IBEC-led alliance created to promote nanotechnology applied to healthcare and biotechnology, BioNanoMed Catalunya, was presented to the media at the Museu Colet in Barcelona. BioNanoMed Catalunya brings together 18 research centres, hospitals and companies to share know-how and resources, facilitate new developments in nanomedicine and gain international visibility for the advances in nanotechnology that are emerging in Catalonia.

Along with Biocat, the Catalan Bioregion agency, IBEC has been developing the initiative since 2009. Among the 37 research groups involved in the alliance are IBEC's Bio/Non-bio Interactions for Regenerative Medicine, Cellular Biomechanics, Nanobioengineering, and Nanoprobes and Nanoswitches groups. As the next ten years will be key in transforming the results of bionanomedical research into more effective diagnostic systems and therapies, new tools to improve the environment or more efficient industrial production systems in the biotechnology sector, BioNanoMed Catalunya's challenge is to effectively coordinate strategies and establish cooperative links.

The alliance's new website, www.bionanomedcat.org, was also presented at the press conference in May. It aims to become a benchmark site in Catalan bionanomedicine, featuring qualitative information on the companies and organizations active in the field, documents and news. In addition, the network's first public activities in 2011 included a presentation to the European policy makers and other cluster representatives at the EuroNanoForum 2011 and participation in Washington's BIO Convention in June.

Several organisations exist at a local or national level to consolidate research efforts in particular fields, coordinate and encourage greater visibility for the activities of research centres, or bring together similar entities with a common goal from different regions.

IBEC is a member or partner of the following organisations and initiatives.

Biopol'H

Biopol'H is a biomedical and biotechnology cluster of health care facilities, knowledge-generating institutions, research centres and companies from the life sciences and health sectors, in a physical environment formed by the Bellvitge Institute for Biomedical Research (IDIBELL), the University Hospital of Bellvitge, the Catalan Institute of Oncology (ICO), the Health Sciences Campus of Bellvitge (UB) and the future Biopol Health Science Park. It is located within the municipality of L'Hospitalet de Llobregat.

A day-long workshop, Nanomedicine for Healthy Ageing, was organised jointly by Biopol'H and IBEC on 19 October 2011. Following on from the 4th IBEC Symposium on Bioengineering and Nanomedicine (page 93), the workshop welcomed experts including Laura Ballerini of the University of Trieste, Scott Parazynski of The Methodist Hospital Research Institute in Houston and Yuri Volkov of Trinity College Dublin. They and the other top speakers, who included Dr. Jaume Campdelacreu from IDIBELL representing the clinical arm of the cluster, led discussions on the potential of nanotechnologies for improved diagnosis and treatments for conditions associated with ageing.

European Technological Platform on Nanomedicine (ETPN)

A voting member of ETPN since 2008, IBEC has contributed as an invited expert body, through its director and the Institutional Projects Unit, to 'Roadmaps for Nanomedicine Towards 2020'. This key document in the area of nanomedicine was drawn up to advise the European Commission on future R&D investment needed to ensure successful translation of the results of research into the related sectors of medical and pharmaceutical technologies.

In 2011 IBEC, in its capacity as manager of NanoMed Spain and coordinator of the Connect-EU Nanobio+Nanomed working group, hosted the annual forum of the ETPN in Barcelona.

HUBc

The Health UB Campus (HUBc) project, led by the University of Barcelona, brings together about 30 training institutions, research and knowledge transfer in health sciences, mainly around the campus of the Medical and Hospital San Juan de Dios, the campus Health Sciences with the University Hospital of Bellvitge, ICO, IDIBELL, Biopol'H, and Barcelona Innovation Zone. On 21 October 2010, HUBc achieved recognition by the Ministries of Education and Science and Innovation as a campus of international excellence.

Its main strength is the high degree of specialization in the field of health, provide attraction of talents and capabilities will add the cities of Barcelona and L'Hospitalet de Llobregat to coordinate, stimulate and promote biomedicine, biotechnology and medical technologies. It offers support to several of IBEC's activities such as the IBEC Symposium on Bioengineering and Nanomedicine and the IBEC-hosted forum of the European Platform on Nanomedicine (ETPN) in 2011.

Interbio

Sponsored by the EC, Interbio is an interregional cooperation programme which aims at fostering transnational cooperation, technology transfer and innovation in the fields of biotechnologies and life sciences in south-west Europe. Interbio brings together research centres, technology platforms and companies from the Barcelona, Bordeaux, Lisbon, Toulouse and Valencia regions.

Nanoaracat

Nanoaracat is a protocol that establishes a framework for collaboration between the regional governments of Aragon and Catalonia to foment and coordinate R&D projects in nanoscience and nanotechnology. IBEC is one of 17 institutions involved in this initiative and is a member of the scientific and monitoring committees.

Events and communications



linking research, technology and life

Transdisciplinary
programmes based on
interdisciplinary and
multidisciplinary research
is mission is to
conduct high quality research
to, and creating
knowledge, contributes to a
better quality of life, improves
health and creates wealth.

programmes
and research

- Transdisciplinary
- Interdisciplinary
- Multidisciplinary
- Transdisciplinary
- Interdisciplinary
- Multidisciplinary

G 200

IBEC Seminars and PhD Discussions

IBEC Seminars

Throughout the year, a number of international experts, scientists who work with our research teams on certain projects and some of the IBEC group leaders are invited to give lectures as part of the IBEC Seminars programme. The aim of these events is to provide an overview of the state-of-the-art research in various fields and to give the audience the opportunity to discuss recent developments with the guest speakers.

■ 14 January

Maria V. Sanchez-Vives, Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), Barcelona
Cerebral cortex network dynamics

■ 4 February

Dr. Daniel Riveline, Laboratory of Cell Physics, Institut de Science et d'Ingénierie Supramoléculaires (ISIS) and Institut de Génétique et de Biologie Moléculaire et Cellulaire (IGBMC), Strasbourg, France
Two examples of cell physics phenomena: cell adhesion and cell division

■ 18 February

Manuel Fuentes, Cancer Research Center, Department of Medicine, University of Salamanca-CSIC
Self-assembling Protein Microarrays and Surface Plasmon Resonance Imaging to study high-throughput protein interactions of p53 and Mdm2

■ 4 March

Prof. Angel Raya, IBEC
Reprogramming the potency of somatic cells: how and what for?

■ 11 March

Sun Nyunt Wai, MD, PhD, Professor of Medical Microbial Pathogenesis, Umeå Centre for Microbial Research (UCMR), Umeå University, Sweden
Pathoadaptive regulation of type VI secretion system in Vibrio cholerae

■ 15 March

Dr. Simon Scheuring, Institute Curie, U1006 INSERM, Paris
Membrane Proteins in Native Membranes Studied by Atomic Force Microscopy (AFM): Watching Biological Nano-Machines at Work

■ 18 March

Alberto Pérez-Alvarez, Departamento de Farmacología y Terapéutica, Facultad de Medicina, Universidad Autónoma de Madrid
Elements involved in stimulus-secretion coupling in human chromaffin cells (at Bellvitge site)

■ 18 March

Dr. Julian Jones, Department of Materials, Imperial College London
Tough scaffolds for bone repair: a hybrid approach to tissue engineering

■ 1 April

Prof. Dr. Arben Merkoçi, ICREA Research Professor, Nanobioelectronics & Biosensors Group, Catalan Institute of Nanotechnology CIN2 (ICN-CSIC)
Nanoparticles for dna, protein and cell sensors

■ 15 April

Prof. Jose-Ramon Sarasua, University of the Basque Country (UPV-EHU), Department of Mining-Metallurgy and Materials Science, Bilbao School of Engineering
Resorbable polylactides for medical applications: crystallinity, phase structure and properties

■ 6 May

Hans Supèr, ICREA Research Professor, Faculty of Psychology, University of Barcelona
Towards bio-inspired early vision for autonomous robot navigation

■ 20 May

Dr. Zeev Karpas, Department of Analytical Chemistry, Nuclear Research Center, Negev, Beer-Sheva, Israel
Diagnosis of diseases and spoilage through measurement of biogenic amines by Ion Mobility Spectrometry (IMS)

■ 3 June

Prof. Jaume Veciana, Institut de Ciència de Materials de Barcelona (CSIC) and CIBER de Bioingeniería, Biomateriales y Nanomedicina

Ultra sensitive piezoresistive sensors for biomedical applications based on composite polymeric thin films

■ 30 June

Sanjay Kumar, University of California

Dissecting and genetically engineering microscale tensional homeostasis in living cells

■ 1 July

Dr. Lluís Orozco, Institut de Teràpia Regenerativa Tissular (ITRT)

Terapia Celular aplicada al aparato locomotor: "Estado del Arte"

■ 14 July

Dr. Christopher Ahern, University of British Columbia

How do S4 segments charge in voltage-sensor domains? Just add water (at Bellvitge site)

■ 15 July

Prof. Antonio Villaverde, Institute for Biotechnology and Biomedicine and Department of Genetics and Microbiology, Universitat Autònoma de Barcelona/CIBER de Bioingeniería, Biomateriales y Nanomedicina (CIBER-BBN), Bellaterra, Barcelona

Towards a tuneable nanoscale architecture of protein-only artificial viruses

■ 7 October

Nadia Mercader, CNIC

Heart regeneration in the zebrafish: scarring and epicardial response upon cryoinjury

■ 4 November

Dr. Roger Guimerà, ICREA Research Professor, Universitat Rovira i Virgili (Experimental Sciences & Mathematics)

Modules and statistical models of complex biological networks

■ 2 December

Jerome Solon, CRG

Closing the gap: Coordination of forces during drosophila dorsal closure

■ 21 December

Eugeni Roura, Queensland Alliance for Agriculture and Food Innovation (QAAFI), Centre for Nutrition and Food Sciences, The University of Queensland, Brisbane, Australia

The taste system beyond taste: novel paths to explain hunger and satiety in mammals

PhD Discussions

These seminars are intended to encourage the participation of PhD students, providing a forum where they can present the results of their research and discuss it with fellow students and researchers. Throughout 2011, eleven PhD students participated in these sessions. Additionally, in order to help the students in their career development and provide them with additional skills, three invited speakers gave lectures on various topics.

Complementary skills sessions (invited speakers)

■ 28 January

Dr. Josep Perelló, Associate Professor at the Department of Fundamental Physics of the University of Barcelona and coordinator of the Science Area at Arts Santa Mònica

Is art a new way of doing science?

■ 27 May

Soraya Hidalgo, European Projects Office, UPC

Responding to Global Challenges: the International Cooperation Research Activities of the European Commission

■ 28 October

Alicia Casals (Robotics) and the General Projects Unit, IBEC

Funding your research. Strategies and funding programmes: the example of the Marie Curie programme

Left-right: a PhD Discussions Complementary Skills Session; question time; Prof. Gustavo V. Guinea



Meetings and outreach activities

Complementary skills training

Throughout the year, IBEC's staff researchers have the chance to supplement their professional expertise at a range of complementary skills courses organised by the Human Resources department.

In 2011, training was focused on efficiency in communication in three main areas: scientific writing, oral presentations, and communicating with colleagues.

- Throughout the year
- IBEC
- 75 people approximately

Connect-EU Nanobio+Nanomed Working Group

A meeting of the Connect-EU Nanobio+Nanomed Working Group, which is coordinated by IBEC (see page 83). During the meeting, the group discussed the first steps towards its aim to provide an expert opinion on the 'hot' topics and the local strengths in the field for ACC10, the agency set up by the government to make Catalan enterprise more globally competitive.

- 27 January
- IBEC
- 23 participants

Jornada de Nanomedicina en España: Presente y Futuro

A one-day workshop, 'Nanomedicine in Spain: present and future' was held at the Center for Industrial Technological Development (CDTI) in Madrid. At the meeting IBEC presented a 'who's who' of Spain's major players in nanomedicine and a record of this new field's most notable

achievements, "Nanomedicine in Spain 06-10", which had been coordinated by the institute in its capacity of leader of the Spanish Nanomedicine Platform (see page 82).

- 1 February
- CDTI, Madrid
- 92 participants

CTP project meeting

A meeting of the transnational project 'Desenvolupament d'eines innovadores per a la Ocratoxina A', coordinated by postdoc Beatriz Prieto of the Nanobioengineering group and funded by the Comunitat de Treball dels Pirineus (CTP).

- 2 February
- IBEC
- 15 participants

EscoLab visit

EscoLab is an initiative of Barcelona City Council's Commission for the Promotion of Scientific Culture. It introduces high school and VET students to the city's research laboratories, with the aim to increase scientific vocation among students.

After a presentation from IBEC Director Josep Planell about the institute and its research areas, the 23 14-15 year olds and their teachers visited the Bio/non-bio Interactions for Regenerative Medicine, Biomechanics and Mechanobiology and Control of Stem Cell Potency groups, where researchers gave them some insights into computational models, cell differentiation, zebrafish as a model organism, and electrospinning.

- 23 February
- IBEC
- 23 participants



Left-right: Meeting of the Connect-EU working group; ESCOLAB; MySpine meeting

BOND project meeting

The third technical meeting of the project 'Bioelectronic Olfactory Neuron Device (BOND)', which is funded by the European Commission under FP7 and coordinated by associate director Josep Samitier, with group leader Gabriel Gomila as technical manager. Seven other partners from France, Italy, Ireland and the UK are also involved.

- 7 March
- IBEC
- 20 participants

NeuroChem project meeting

Meeting of the project 'Biologically Inspired Computation for Chemical Sensing (NeuroChem)', which was funded by the European Commission under FP7 and coordinated by Artificial Olfaction group leader Santiago Marco.

- 9-11 March
- Hotel Senator, Barcelona
- 75 participants

MySpine project meeting

The kick-off meeting of the project 'Functional prognosis simulation of patient-specific spinal treatment (MySpine)', which is funded by the European Commission under FP7 and coordinated by Biomechanics and Mechanobiology group leader Damien Lacroix.

- 22 March
- IBEC
- 20 participants

Recerca en acció

An education fair organised by the Catalan Foundation for Research and Innovation to demonstrate the results of scientific and technological research being carried out by universities, research centres, businesses and other organizations, and to promote science and technology careers among young people.

In 2012 IBEC shared a stand with other Catalan institutes in an initiative organised by ACER (see page 84).

- 26 March
- Fira de Barcelona
- 70000 visitors

School visit

A visit to IBEC of 24 students from Escuela IES Ramón Cid.

- 31 March
- IBEC
- 24 participants

Fira Recerca en Directe

The 'Live Research' fair is organized by the Parc Científic de Barcelona (PCB) with the support of the Obra Social Caixa Catalunya bank. It aims to improve understanding and awareness of science by presenting Barcelona research to the general public, with researchers manning the stands to demonstrate and explain their methods and goals in an accessible way.

In 2011 scientists from IBEC's Control of Stem Cell Potency group attended the fair, where they introduced visitors to the zebrafish as a model organism. Under a stereomicroscope visitors were shown embryos at different stages of development, including transgenic embryos displaying fluorescent hearts.

- 5-7 April
- La Pedrera, Barcelona
- 1200 visitors

Student visit

A visit to IBEC of nine Genetic Engineering masters students from the UPC.

- 13 April
- IBEC
- 14 participants

Fira d'Empreses

This careers fair, organized by the University of Barcelona's physics and chemistry faculties, helps undergraduate students of these subjects to find out more about potential employers or furthering their studies, as well as improving the university's relations with the business sector.

IBEC attended the fair to offer university leavers advice and information about continuing their career at the institute as masters or PhD students.

- 5 May
- University of Barcelona
- 250 visitors

Connect-EU Nanobio+Nanomed Working Group

A further meeting of the Connect-EU Nanobio+Nanomed Working Group.

- 26 June
- IBEC
- 20 participants

E2C3 Youth and Science Programme

Three high-school students were hosted in IBEC labs for several weeks in July as part of Catalunya Caixa's E2C3 Youth and Science Programme, which exposes talented and motivated young students to 'real' scientific work to encourage more of them to embark on a scientific career. Laia Gil, Joaquim Viñes and Laia Gili joined researchers Melba Navarro and Cécile Perrault for some hands-on

experience in the contribution of microtubules to cellular forces and the characterisation of biodegradable materials for bone regeneration.

- 2-4 weeks in July
- IBEC
- 3 participants

IBEC Makes a Splash

IBEC Makes a Splash day on 28 July heralded the start of the summer break and gave staff and researchers alike the chance to get together to play sport, take some exercise, learn a new skill or simply lounge by the pool.

The event, which ended with a buffet and toasts, was the ideal opportunity for IBEC to celebrate its great achievement of getting to the first round of the MICINN's Severo Ochoa selection.

- 28 July
- University of Barcelona's sports ground, Esports UB
- 80 participants

Warwick University visit

Following the signing of a Memorandum of Understanding between the two institutes last year (see page 81), IBEC played host to visitors from the University of Warwick in September. Nigel Stocks, Christopher James, Jianfeng Feng, Pat Unwin and Pam Thomas from the UK-based institution took part in some high-level meetings with IBEC's directors and some lab tours, as well as presenting their science to a gathering of IBEC researchers.

From the IBEC side, Gabriel Gomila, Pau Gorostiza, Agustin Gutiérrez, Josep Samitier and Raimon Jané presented their work, and the event proved a ideal opportunity to identify future collaborations and discuss the exchange of knowledge and personnel.

- 22-23 September
- IBEC
- 9 participants

4th IBEC Symposium on Bioengineering and Nanomedicine/Nanomedicine for Healthy Ageing

The IBEC Symposium is a forum, open to the whole scientific community, where internationally renowned experts present their recent results in bioengineering and nanomedicine. It also offers a platform for the institute's young researchers to present their work and get feedback from more experienced scientists.

Over 250 people attended the 4th IBEC Symposium on Bioengineering and Nanomedicine, with more than a third coming from outside the institute. A total of 71 young researchers presented posters, and 27 of them also gave oral presentations of their work. The second day of the symposium was co-organised by Biopol'H (see page 85) and was devoted to the topic of Nanomedicine for Healthy Ageing.

- 18-19 October
- Hospital de Bellvitge
- 250 people
- 71 posters

ETP Nanomedicine General Assembly and Annual Forum

The European Technological Platform on Nanomedicine (ETPN; see page 85) General Assembly and Annual Forum on 19-21 October, which IBEC also organised, followed on from the IBEC Symposium at the Hospital de Bellvitge.

- 19-21 October
- Hospital de Bellvitge
- 100 participants

PathoGenomics project meeting

A meeting of the project 'Identification of hot spots of divergence and rapidly changing genes within Shiga toxin-producing *E. coli*', which is funded by the European Commission's ERA-NET PathoGenoMics initiative. Senior researcher Eduard Torrents of the Microbial Biotechnology and Host-pathogen Interaction group is the IBEC partner.

- 9 November
- IBEC
- 10 participants

IBEC Christmas Party

- 16 December
- Poliesportiu, UPC
- 160 participants

Left-right: Fira Recerca en Directe; the fourth IBEC symposium; the University of Barcelona's physics and chemistry careers fair



Communications

www.ibeccbarcelona.eu

The IBEC website, www.ibeccbarcelona.eu, underwent a design and content overhaul in 2010-2011. Launched in May 2011, the new-look site has a clean new design with a dynamic homepage and several new sections. The homepage displays the latest news, events, press releases and scientific publications, and the jobs section is now more visible and intuitive.

New sections include Technology Transfer and Training, and all IBEC news items, media coverage and press releases are available to refer to in the easy-to-use chronological archive. A Documents and Downloads page offers all IBEC publications including the InsideIBEC newsletter, Annual Reports, the PhD brochure and associated documents to view online or as downloads.

The research group pages were also extensively overhauled and are now divided into six tabbed sections: group description, members (including an option to display former members), publications, projects and collaborations, protocols and equipment, and news. With this format, information is easier to find and the amount of detail that may be included is unlimited.

Some sections of the new website are still under development. It is intended that each area of Support Services will have a dedicated page to explain their activities and the services they offer to IBEC's researchers; a "Want to visit IBEC?" page will be added for schools and other potential visitors; and the Templates page will provide logos and branded IBEC templates such as presentation slides and headed paper. In addition, an online 'press area' of expert opinions, images and videos in bionengineering and nanomedicine will be established.

IBEC Facebook page

In 2011 IBEC opened its own Facebook page, which by the end of the year was running successfully with over 180 'friends'. The Facebook page is intended to provide a forum for more community and social news, and also to act as a tool to enhance visibility among potential new young recruits.

Attract Talent Scheme

In autumn IBEC produced a PhD brochure and poster as part of a new campaign to attract talented young researchers to the institute. The brochure includes information about the PhD system in Spain, the benefits of doing a PhD at IBEC, which study programmes are open to researchers, and how to apply, as well as testimonials from past students.

The brochure and accompanying publicity materials will be disseminated at conferences, meetings, fairs and to relevant institutions with undergraduate and masters students, and a dedicated PhD webpage has been created.

Merge of events and communications units

At the end of 2011 IBEC's events and communications departments merged to become the Communications and Outreach Department. As well as continuing to perform the existing tasks in both areas and some Human Resources services, the new unit will extend its efforts into other fields, particularly improving IBEC's record of participation in outreach activities, internal communication and encouraging a community spirit, exploring new technologies, and media relations.

Left-right: The new IBEC Facebook page and website; the PhD brochure and poster for the Attract Talent Scheme



Media coverage 2011

■ January

Ràdio 4 16/01/2011

An interview with Biomechanics and mechanobiology group leader Damien Lacroix about the new EU-project he coordinates, MySpine, was broadcast on Ràdio 4's L'Observatori programme.

E-News Biocat 20/01/2011

"Nanomedicine: Where Nanotechnology, biotechnology and the health sciences come together"
IBEC associate director Josep Samitier was a contributor to the January edition of Biocat's e-newsletter.

■ February

RecercaCaixa 13/02/2011

Group leader Pau Gorostiza featured in a short video produced by funders RecercaCaixa about his project 'Development of light-modulated ligands for remote, non-invasive regulation of neuropathic pain'.

El 9 Nou 21/02/2011

"Cal connectar les mans robotiques amb el nervi perquè rebin ordres"
Robotics group leader Àlicia Casals appeared in Catalan local paper El 9 Nou, which covers the Osona/Ripollès and Vallès Oriental areas.

■ March

Research*EU 01/03/2011

"Protecting nanotechnology research results"
IBEC's FP7 project on technology transfer, Nano2Market, was featured in the Commission's Research*EU magazine supplement (Vol. 30, December 2010/January 2011).

El Mundo 02/03/2011

"Estamos hechos de vidrio"

In a study published in PNAS, group leader Xavier Trepat reveals that migrating cells in our bodies behave in a remarkably similar way to glass when it is heated and cooled. Spanish national newspaper El Mundo covered this story in March.

■ April

Nature Jobs 06/04/2011

"Keeping Catalonia's research revolution on track"
IBEC featured in a Nature Jobs article, Spotlight on Catalonia, which asked how the region is coping with Spain's financial crisis, having fostered a successful research hub in a relatively short time.

El Periódico 11/04/2011

"Sin un andamio de apoyo"

IBEC associate director Josep Samitier was an expert opinion quoted in El Periódico regarding a story about a Japanese study that succeeded in growing an embryonic eye from the stem cells of mice.

El País 12/04/2011

"Imaginenano 2011: Primer evento global en España de nanociencia y nanotecnología"
Coverage in El País of Imaginenano, one of the largest European events in nanoscience and nanotechnology which took place on 11-14 April at Bilbao Exhibition Centre, in which IBEC took part.

ENT Today 18/04/2011

"System Automatically Monitors Apnea-Hypopnea Index"
Research by the Biomedical Signal Processing and Interpretation group featured in the section 'Literature Review: A roundup of the most important recent studies' of ENT Today magazine.

Diario Medico 26/04/2011

"La nanomedicina, clave del diagnóstico precoz"
An article entitled "Nanomedicine, the key to early diagnosis" including an interview with IBEC associate director Josep Samitier appeared in Diario Medico.

■ May

Interbio website 09/05/11

“Feedback on Interbio cross-border research projects”

Postdoc researcher in the Nanobioengineering group Antoni Homs was asked to give some feedback to be published on the website of the collaborative project Interbio.

La Vanguardia 13/05/2011

“Descubierta una nueva célula en el cuerpo humano”

IBEC group leader Ángel Raya was quoted in an article in La Vanguardia about recent research from Harvard that has discovered a cell type previously unknown in the human body.

TV3 16/05/11

The official press launch of BioNanoMed Catalunya, the IBEC-led platform to promote synergies between groups, universities, hospitals and companies doing research in nanotechnology applied to health and biotechnology (page 84), featured in the lunchtime news on TV3 on 13 May.

Ara 30/05/11

“Volem que el nostre coneixement es traslladi al sector de la salut”

In the Catalan newspaper Ara, IBEC associate director Josep Samitier was interviewed for a full-page feature. In it, he tells journalist Joan García about the history and goals of IBEC, its successes and the challenges it faces.

■ June

La 2 02/06/11

Angel Raya and his Control of Stem Cell Potency Group appeared in an edition of the tres14 program on national TV channel La 2, which was devoted to the subject of stem cells.

El Global 15/06/11

“La alianza ‘BioNanoMed Catalunya’ une a 18 empresas e instituciones”

In its June edition, El Global, the most prominent journal on the pharmaceutical sector in Spain, featured a news item on the IBEC-led alliance BioNanoMed Catalunya.

SEBBM 16/06/11

“Nanomedicina: nanotecnologías aplicadas a la salud”

An article by IBEC associate director Josep Samitier, ‘Nanomedicina: nanotecnologías aplicadas a la salud’ appeared in SEBBM, a periodical published by the Sociedad Española de Bioquímica y Biología Molecular.

Destacamus 16/06/11

“Xavier Trepà, investigador principal del Laboratori de Dinàmica Cel·lular i del Teixit de l’IBEC”

IBEC group leader Xavier Trepà was the subject of an edition of Destacamus, a bimonthly magazine published by Biopol’H which profiles researchers.

■ July

La Vanguardia 04/07/11

“Mejorar la vida y potenciar empresas”

An article about BioNanoMed Cat appeared in La Vanguardia’s Dinero supplement on 19 June, in which Josep Samitier and the director general of Biocat, Montserrat Vendrell, explain the aim of the IBEC-led alliance.

Recercat 07/07/11

“Líders en recerca: Pau Gorostiza, aportant llum a l’activitat cel·lular”

Nanoprobes and Nanoswitches group leader and ICREA professor Pau Gorostiza is featured in an interview in Recercat, the online newsletter of the Commission for Universities and Research of the Ministry of Economy and Knowledge.

Teraflop 15/07/11

“L’estudi de l’efecte biomecànic sobre el cos humà”

The Biomechanics and Mechanobiology group’s work and Damien Lacroix’s recent ERC grant was the subject of an article in July’s Teraflop, the magazine of the Centre de Serveis Científics i Acadèmics de Catalunya (CESCA).

FET 22/07/11

“NEUROchem’s new avenues to chemical sensing”

The Neurochem project, Biologically inspired computation for chemical sensing, was featured in the July edition of the FET (Future and Emerging Technologies in Europe) newsletter which is published by the European Commission.

La 1 22/07/11

The MICINN meeting in Madrid, which invited the directors of the Severo Ochoa shortlist, was featured on the lunchtime news bulletin Telediario on national TV channel La 1 and appeared in several newspapers.

El Periódico 25/07/11

“Un robot tiene que portarse de forma agradable”

PhD student Xavier Giralt was interviewed for the ‘Gente corriente’ section on the back page of El Periódico.

Diario Medico 26/07/11

“Identifican una interacción molecular esencial en el desarrollo de la epilepsia”

The Molecular and Cellular Neurotechnology group's paper on the development of epilepsy made the news in Diario Medico, Spain's leading newspaper for health professionals.

■ August

BBC 05/08/11

“Back pain and disc health ‘linked’ to lack of nutrients”

The Biomechanics and Mechanobiology group's paper in PLoS Computational Biology made the BBC news. Andrea Malandrino, Jérôme Noailly and group leader Damien Lacroix's paper, ‘The effect of sustained compression on oxygen metabolic transport in the intervertebral disc decreases with degenerative changes’ describes results that could help to predict the onset of spinal disc degeneration.

youris.com 29.08.11

“From wood to bone”

Elisabeth Engel, Senior researcher in the Bio/non-bio interactions for regenerative medicine group, was interviewed for the European Research Media Center's website, youris.com, for her expert response to some research into bone regeneration conducted by researchers in Italy.

■ November

Catalunya Ràdio 02/11/11

Robotics group leader Alicia Casals was interviewed on the Catalunya Ràdio programme “El Café de la República” in November. This popular evening programme discusses the news of the day and the ‘hot topics’ of the moment.

TVE2 10/11/11

On 23 October, IBEC's Robotics lab was featured in an episode of ‘Emprendedores e innovadores’ on TVE2, when visiting masters student Paloma Fuentes gave viewers a tour of the robot kitchen with the help of IBEC PhD student Manuel Vinagre.

■ December

The Discovery Channel 07/12/11

The Discovery Channel's Daily Planet programme on 28 November featured a report about the LOTUS project, of which IBEC group leader Santiago Marco is a partner.

TV3 13/12/11

IBEC's research was featured on the TV3 news in an item filmed to highlight the ‘La Marató de TV3’ telethon.

youris.com 14/12/11

“A patient-specific predictive platform to treat back pathologies”

The European Research Media Center's website, youris.com, featured an article about the MySpine project, which is coordinated by IBEC group leader Damien Lacroix.

Left-right: group leader Xavier Trepot in *Destacamus*; filming in the Control of Stem Cell Potency lab; the Robotics lab on TVE2



Notes

Notes

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