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FORUM BIOREGION 2016

SUMMARY OF TALKS

#ForumBioRegion

During 2016 Forum of the BioRegion, held in November 2016, international experts presented successful public-private partnership experiences and discussed on where the biopharma, medtech and digital health subsectors are heading. In this document, you will find a summary of all the talks that took place in this Meeting, that was conceived to allow assistants to stay up-to-date, discover new ways to grow and identify opportunities, and be prepared to face the complexities of the constantly healthcare changing sector.

Adding Value through Partnerships: the MedCity Experience

SIMON HOWELL, *MedCity*, *Founding Non-Executive Director* | *King's College London*, *Guy's Campus Dean (United Kingdom)*

See his presentation

MedCity is an initiative that was launched in 2014 to grow the life-sciences cluster of England's greater southeast. It is a collaboration between the Mayor of London and the capital's three Academic Health Science Centres — Imperial College Academic Health Science Centre, King's Health Partners, and UCL Partners. New additions include research centers and institutions in Oxford and Cambridge, which with London form what is known as the *Golden Triangle*.

The aim of MedCity is to promote new public-private partnership models and projects to drive entrepreneurship and business-mindedness among researchers. To do so, MedCity, which is set up as an independent company,

- brings together scientists and businesspeople from different areas to work on projects with the potential for collaboration and development,
- helps foreign companies connect with the local ecosystem and research resources in southeastern England,
- promotes innovation and growth through seed investment, business angels and venture capital,
- provides guidance on accessing the UK market and British National Health Service (NHS), and on complying with regulatory requirements, sharing lessons learned from previous processes,
- facilitates international contacts in the biosciences and medical technology arenas,
- connects companies with the best researchers in the world in fields of mutual interest.

To measure the success of MedCity, a broad panel of indicators has been established:

- Increase in the number of clinical trials and patients recruited
- Number of large and small companies in London (early-stage development and manufacturing) and number of collaborations with academia and the NHS
- Increase in number of spin-outs in London and internal investment they receive

- Number of international companies in the Golden Triangle
- Active community of investors in bioscience
- Increase in high-value jobs in London
- Number of new therapies that are available to patients more quickly

Simon Howell, who in his speech put the potentially negative impact of Brexit into perspective ("*In the long term, what is most important is to guarantee the flow of people and ideas and I'm sure we'll be able to do that*."), shared two practical examples of the work MedCity has done so far.

The first is the **"Collaborate to Innovate"** program, which promotes collaboration between innovative SMEs and universities in response to two gaps in the market: the lack of funding for innovation and the difficulties small companies face in accessing top-notch educational institutions. The program, co-funded by the European Union and the Higher Education Funding Council for England (HEFCE), received 70 submissions in its first call for proposals (September 2016) and is funding 15 of them.

Characteristics:

- Funding **15 projects**, **£100,000 each**, in fields like medical devices, diagnostics, digital health and drug discovery
- The program seeks out academic collaborations that suit the selected projects.
- Adapts to the needs of SMEs, instead of them having to adapt their projects to the conditions of the call
- SMEs don't have to come up with matching funds.

The second project Howell presented was a study carried out by MedCity on the availability of space to incubate companies (current and projected for 2018-2020) in London as compared to Paris, Berlin, New York and Boston. The first thing the study showed was that London today is far behind the other cities analyzed (with 5 or 6 times less space available than New York and Paris, and 20 times less space in Boston). But the second, more interesting, result that can surely be applied in other cities that, like Barcelona, hope to compete in the international life-sciences market, was:

"Conducting this study allowed us to realize that the competition isn't between north London and west London. It's between London and other large international hubs in the sector. And being aware of this has changed our priorities in terms of policy and investment," concluded Simon Howell. ■

Future trends and trending topics in the life sciences and healthcare industry

(1) Breaking up pharma's value chain - what can we expect

MICHAEL MÜLLER, *Monacon Beteiligungs GmbH*, *Managing Partner (Germany)*

See his presentation

Changes in the pharma sector have some key activators:

- **Exponential growth of health-related needs** of the global population: China is expected to have a middle class of more than 1 billion people by 2020 and there will be 75 million diabetics in India by 2025 (currently 8 million).
- At the current pace, the cost of healthcare could reach **30% of the GDP** by 2050.
- **Pharma investment in R&D has quintupled** in the past 20 years, while yielding a similar number of new drugs.
- The **economic value** of large companies has fallen, benefiting **highly specialized small businesses**.
- There has been **no noteworthy innovation** in the past 20 years in important therapeutic areas (high blood pressure, Parkinson).

The traditional value chain in pharma corporations, with a comprehensive model in which one company carries out all of the phases, from drug discovery to market, is broken. Instead, **strategic collaborations are forged in all areas**, with an increasingly diversified group of partners that is **making it necessary to review conventional intellectual property** (IP) **management schemes**.

In his speech, Michael Müller highlighted **five general areas** at the core of the shift the pharmaceutical industry is experiencing:

- **Genome sequencing and personalized medicine are revolutionizing diagnosis and treatment**

  Medicine is becoming stratified because most drugs only work in 60-70% of patients. The other 30-40% need new approaches, made possible by knowledge of the genome, but this means the end of blockbusters. 10 years ago, the biggest selling drugs generated some $10 billions per year in income; now, the biggest earners barely hit $3 billions per year. But genome sequencing is also leading to a paradigm shift, with personalized treatment instead of drugs, with examples including Beta-cell transplants to restore the pancreas' ability to produce insulin or vaccines to activate the immune system to attack cancer cells.

- **Prevention will become a key market segment and ICT companies will become key partners for pharmaceutical corporations**

  Mobile technology (not only apps but also bioseals and implantable chips) will promote prevention and monitoring of diseases and rehabilitation. A combination of sophisticated data-analysis systems and sensors will help prevent, for example, a diabetic patient from developing the typical foot ulcers, and genomic analysis will allow us to know a person's predisposition and risk of developing diseases from birth, with all of the social and political questions that opens up. There are already joint ventures (for example, between Google-owned company 23andMe and Pfizer) to facilitate development of new drugs from mass genomic data. And this poses new issues regarding data ownership and the rights and role of patients in these new business models.

  Furthermore, new collaborations are being forged between pharma and medtech companies to develop drug administration technology (Proteus + Oracle + Medtronic + Novartis) or to monitor adherence to treatment (Boehringer + AdhereTech). Other new partnerships also include social media (PatientsLikeMe + Genentech) to collect medical data for research or technology giants (Samsung + Quintiles) in deals that range from distribution to biosimilars.

- **New shared risk models will be developed**

  Discounts, maximum spending agreements and reimbursement are some of the formulas that are already being used to tie payment for drugs to their results.

- **Pharma companies are moving from a conventional, centralized sales and R&D model to one focusing on innovation generated outside of their traditional strengths**

  Open innovation has created a whole new landscape, which requires different IP management models that are shared. 70% of projects pharma companies have in Phase I come from external collaboration (academia, start-ups) and joint ventures focusing on genomics and personalized medicine are becoming increasingly common.

- **The secrecy seen in the past has been replaced by a clear commitment to open access**

  Pharmaceutical companies like GSK, AstraZeneca and Johnson & Johnson have consented to share data from clinical trials on the cloud, which allows new stakeholders to use this information to advance innovation.

In short, Müller concluded, it will be the convergence of **data** (and associated technology), **genetics** and **drugs**, under the framework of **personalized medicine**, that will lead to radical changes in the pharma industry, both in terms of business model and production processes. The fourth element in play is **accessibility**, as only 10% of the world's population consumes 90% of its resources, a situation that is probably not sustainable and leads us to expect a radical restructuring of international markets.
■

(2) Medtech 2016: Current Trends and Emerging Paradigms

DAVID CASSAK, *Innovation in Medtech LLC*, *Managing Partner (USA)*

The **United States** continues to be the **largest medical device market** in the world, with joint turnover at **$150 billion** a year, accounting for approximately 43% of the global total. But it is a market that is changing very quickly, which has seen two waves of important changes: the first around 2000 and the second as a result of the crisis of 2008. New developments in digital health seem destined to spark another wave of changes in the very near future, says David Cassak.

Around 2000, there was a crisis of knowledge in large medical technology companies and many investors pulled out, which led to mergers. The big players diversified their production, both in terms of technology and therapeutic areas, and instituted a new business model in which start-ups were the drivers of innovation, which was later brought into the large companies who were experts in marketing and distribution.

This period was characterized by its:

- Incremental innovation, which reached the market easily (in under two years)
- Few regulatory hurdles and simple reimbursement models
- Market concentrated in the US
- New technology easily adopted, given physicians' decision-making power

Towards the end of the decade, the impact of the financial crisis and budgetary pressures on the healthcare sector led to cracks in this model.

- Decision-making power moved from physicians to buyers (hospital management, insurance companies, the government).
- Companies became successful by helping buyers face spending pressures (through discounts, standardization or limiting the use of the devices) and proving that they provided more value for the patients.
- Incremental innovation was no longer enough to penetrate the market.
- Since 2008, there's been a significant reduction in venture capital (VC) in the sector, both in Europe and the USA, especially in the early stages, which opens the doors to investors from other areas, particularly Asia (China, Singapore, etc.).
- There was a strong contrast between the United States and Europe, where some countries (Germany, Ireland) set up programs to promote the medtech sector, making up for the lack of funding in the early stages.
- European VC found new opportunities in the United States thanks to decreased investing by American funds.

And what is the situation today? Who are the drivers in the sector?

- **Large mergers and acquisitions to gain critical mass**, a process of concentrating power that greatly reduces the market for small innovative start-ups and forces them to contact large companies much earlier on.
- The great challenge now is addressing **chronicity** and **extending the value** of the device in the **long-term**, which means extending the process prior to the disease (prevention) and providing **post-implant** and **follow-up services**.
- **Shared risk** formulas have been expanded and, in the United States, healthcare reform has opened up new business models, often tied to implementing **new digital technology**.

Cassak believes that digital health is destined to radically transform the medical device sector because:

- It allows for new developments, at a relatively low cost, to increase the **connectivity of the devices** (wearables, telemedicine, providing service in different places, integrating big data).
- It helps address **management of chronicity** (CRM, monitoring patients).
- It has a different **client** (which is no longer the physician or service provider, but the patient).

This means competition will be supplanted by **collaboration among companies**, often from different areas, and lead to **new players** getting involved, which seemed unthinkable until recently, such as Google and Apple. Nevertheless, Cassak believes there is still room for innovation that is not directly tied to the digital arena and points to three paths for the future:

- **"Traditional" technological/clinical innovation**, where he predicts groundbreaking new developments in areas like cardiology and spinal surgery.
- **Systems innovation and improved efficiency**, mainly associated with providing services, monitoring patients and new healthcare locations (telemedicine).
- **Innovation in digital health**, through sensors and mobile apps that offer constant monitoring, more patient control and greater importance of diagnostics in treatment, but also change the stakeholders in the sector and force medtech companies to rethink their approach. ■

(3) Healthcare Evolution: What is Different This Time

VISHAL GULATI, Draper Esprit, Venture Partner; Horizon Discovery Group PLC, Board Director (United Kingdom)

See his presentation

What we mean when we talk about **digital health**? We're talking about products and platforms that take advantage of **connectivity**, **data aggregation** or **analytics** to improve patient experience or how diseases are treated.

The sector is benefiting from:

- **Technological changes** (widespread use of smart phones, falling costs of DNA sequencing, maturing analytics and data-management security)
- **Wide-reaching social trends** (soaring health care costs, the ageing population, baby boomers willing to pay for quality of life)
- **Panorama of opportunities** (availability of an industry and investors interested in new consumer products [B2C])
- **Interesting stage of development** (growth in the US market and beginning of the EU market, globally applicable technology, attractive valuations)

This has led to an increase in investment, which in the past 5 years has surpassed that seen in the medical device and diagnostics sectors, with companies like Flatiron ($313 millions) and 23andMe ($226 millions) leading the market that generated more than $5.7 billions in 2015.

Some of the most noteworthy elements driving the sector, according to Vishal Gulati, include guidelines from the FDA, EMEA and NHS, which have clarified the regulatory path and made market access easier; digitalization of US healthcare giants, like Kaiser; huge investment from corporations like Qualcomm, Bluecross, Google and Novartis; and projects based on big data (Biogen-Roche, IBM Watson, etc.).

Gulati believes these elements are more important than intellectual property, "because in this arena it is perfectly possible to start up a company with very little IP." And, in fact, successful digital health projects are scattered very equally over a matrix that ranges from **technological innovation** to **innovative business model**, from services for companies (**B2B**) or services directly targeting consumers (**B2C**).

In this current environment, in which many diseases still have no cure but life expectancy has increased exponentially for those diagnosed with cancer, for example, what does digital healthcare technology contribute? Two basic changes:

- **Medicine** has become a **science of data**: genomics, big data, laptops, personalized medicine and precision medicine.
- A **cultural change** has come about in terms of **privacy**, **democratization** of medicine, **control** and **accountability** of healthcare professionals and the **end of exceptionality** in the provision of healthcare services.

Regarding data, Gulati reminded the audience that plummeting prices for genome sequencing are at the core of the development of personalized medicine. But he also noted the power of social media, giving the example of a study recently carried out in the US on Facebook, which identified six different types of diabetes sufferers and collected data from them to be analyzed.

Furthermore, unlike what people often think, many patients are willing to share this type of data (up to 94% is willing to do so with their doctor if that can help improve healthcare and 84% is open to sharing medical data with companies to use to develop new treatments).

However, at the same time, these patients demand total access to their medical data, which up to now they haven't been allowed. People are calling for **participative medicine** and are changing their outlook on disease, above all chronic conditions, which are no longer hidden but displayed openly (prosthetics and devices).

In this cultural context, according to Gulati, there are three keys for the future of medicine:

- The use of data to give patients, who've now become clients, **control over the quality of their healthcare professionals and the system as a whole**.
- The move from mass medicine to **personalized medicine**, thanks to genomics and stratification.
- **One billion new clients** joining healthcare systems, through mobile technology, (people who previously had no medical coverage).

And one conclusion:

"The future of healthcare will come from the collaboration between patients and healthcare professionals using digital technology and taking advantage of the available mass data banks." ■

Successful models of public and private collaboration. Learning from the best on tech transfer and science commercialization (1)

SUSAN W. BANNISTER, *Massachusetts Life Sciences Center*, *Former President and CEO (USA)*

See her presentation

"If public investment really focuses on what the private sector needs, we get the leverage necessary to multiply funds." This has been one of the keys behind the success of the Massachusetts Life Science Center (MLSC), explained Susan W. Bannister. This 10-year, $1 billion initiative was launched in 2008 by then-Governor of Massachusetts Deval Patrick.

The MLSC has managed **$595 millions** in investment (2008-2016), with a leveraging rate of x3.3. This has made Boston one of the leading life-sciences clusters in the US. *"We've gone from being an academic hub to being a start-up hub,"* explained Bannister during her presentation.

Other key elements of the MLSC's success included focusing their actions on:

- promoting the **growth of innovative start-ups**, which have acted as a **magnet for large corporations** that have moved to Boston and strengthened the ecosystem
- prioritizing the **creation of job opportunities** for workers with different levels of training
- benefiting the academic community by promoting **translational research**, **entrepreneurship** and **collaboration with industry**
- seeking out the support of experts to identify the best investment opportunities, which has created a sense of shared ownership

The overall goal was to **develop the ecosystem**, identifying and acting in areas that pose essential challenges to achieving this, always taking into account: "*The most interesting innovation comes about when different sectors interact*." This is why the MLSC's most important goal has been to **facilitate** this type of **interaction** and **provide solutions to problems** facing the various stakeholders, "*even when the tools and resources to do so weren't ours.*"

These efforts have yielded great results:

- Employment in the Massachusetts life sciences sector is up 18% (2006-2014) compared to just 2% in other sectors.
- 17,363 new jobs per million inhabitants (2010-2013), 1.3 times higher than the next state (New Jersey)
- Number one in the US in University start-ups (more than 60 in 2013)
- More than $5 billions in seed and early-stage capital (2010-2014), ahead of San Francisco and Silicon Valley

- More than 2,000 job offers per day in the life sciences sector in the Boston area, with 26% of employment generated by people with high school degrees or vocational training (Masters and PhDs)
- 18 out of 20 large biopharmaceutical corporations have a noteworthy presence in Boston (where most had no headquarters at all before 2007)

The actions carried out to promote these results have focused on five strategic areas:

- **Translational scientific research**, with $14.8 millions invested to support the careers of researchers, to hire professors for several universities and medical schools and to fund university/enterprise collaboration projects.
- **Entrepreneurial culture**, which has been promoted by funding Business plan competitions ($2 millions) at several universities; programs to limit risk in newly created companies (with between $50,000 and $200,000 for seed companies and loans of up to $1 million to accelerate projects); and investment to boost business growth: $22.7 millions invested in 50 early-stage companies (which raised a total of $180 millions) and tax incentives valued at $109 millions in exchange for creating new jobs.
- **Training the local workforce** by organizing courses and activities in schools at all levels, providing funding for facilities at vocational training schools and universities, and giving those with research degrees the opportunity to gain "real workplace experience". In total, $12 millions have gone to fund 3,000 internships and 25% of the participants have come out of the program with firm job offers.
- **Capital and facilities:** MLSC has invested more than $95 millions to build laboratories and facilities at universities, mobilizing $390 millions in funds for capital projects. Since 2007, the market has gained more than 650,000 m^2 of laboratory space in Massachusetts.
- **Ecosystem:** *"One of the MLSC's main goals has been to transform a cluster —a collection of assets that is significant but doesn't feel like they are part of a community— into a true ecosystem."* Bannister believes the key elements to achieve this are a **clear, ambitious goal**; the capacity to align different stakeholders around a shared **value proposition** and **well-defined competences**; a **clear message** for public and private stakeholders; and **incentives** to make the ecosystem attractive.

Beyond the results obtained, Bannister believes that organizations like the MLSC are necessary even if they have fewer resources. *"We have benefited from the fact that one organization had a global vision of the innovation system in Boston. We always need a body to help bring together individuals and encourage them to work together, to identify transversal challenges and needs, and that is able to mobilize different desires to find solutions."* ■

Successful models of public and private collaboration. Learning from the best on tech transfer and science commercialization (2)

ZAYNA KHAYAT, MaRS Discovery District, Health System Innovation; MaRS EXCITE, Director (Canada)

See her presentation

MaRs (Medical and Related Sciences) is a public-private partnership –through private initiative- that was created to **address the lack of ability to market the knowledge** generated in the university and research system in Toronto (Ontario, Canada), when a collective effort was made to move from an industrial economy to a knowledge economy in the early 2000s.

"For many years, we've lived with the paradox that economic policy and the healthcare system weren't on the same page," explained Zayna Khayat. She also reminded those present that Ontario spends $50 billions per year on its healthcare system (5 times more than Catalonia for a population of 14 million.)

Initially located in a building that was formerly home to the Toronto General Hospital and has been expanded several times, the MaRS Center occupies **140,000 m^2** of space and is home to more than **200 organizations** —from start-ups to multinational corporations, as well as public research institutes and support bodies— where over 6,000 people work. MaRS is located at the heart of the **"discovery district"**, which is also home to the University of Toronto (with more than 72,000 students), hospitals and several local and state-level government services.

MaRS Center has several **incubation spaces**, including the JLabs Incubator that Johnson & Johnson opened this year, with nearly 4,000 m^2 to incubate between 50 and 70 start-ups working in healthcare, medical technology and digital health. So far, **MaRs has supported approximately 1,000 start-ups** through its various programs, **25%** of which are in the **healthcare sector**.

A separate company has been set up to complement MaRS's work in supporting entrepreneurs: **MaRS Innovation**, which promotes **technology transfer** and **joint ventures with industry**. MaRS *"creates"* healthcare institutions and companies so that entrepreneurs' inventions can be adopted and to close the innovation circle, specifically working to tackle **bottlenecks in the system**:

- Reimbursement
- Public procurement
- Funding
- Access to data and IT systems
- Leadership and policy

In order to address these challenges, MaRS is working in three overarching areas: politics, solutions and skills.

Khayat gave several examples of MaRS programs, including:

- **MaRS EXCITE**, a platform that brings together those that manage the Canadian healthcare system, regulatory bodies, tens of companies and more than 50 healthcare bodies (hospitals and other service providers) to promote innovation. MaRS EXCITE encourages connections between innovators and medical researchers to get data to help validate proposed new technology and decide on the best conditions in which to offer it to ensure it will be adopted.

- **Procurement Co-Design** is a program that detects unmet needs, seeks out companies that can address them and gives each project $50,000 for prototyping and adoption to help make sure the solution reaches the market.

- **Health Outcomes Financing**: MaRS is also working to promote payment by results in the government and those in charge of several healthcare programs (high blood pressure, mental conditions, etc.), coordinating program development and seeking early-stage funding to launch them.

Khayat believes that all of these programs share a focus on viable solutions to real problems. *"We want to go from a knowledge economy to a solution-based economy that addresses great social challenges and creates value for the whole system."* She finished off with a piece of advice: *"We have to be brave and tackle real problems"*. ■

Successful models of public and private collaboration. Learning from the best on tech transfer and science commercialization (i 3)

KEY PHRASES FROM THE DEBATE BETWEEN SUSAN BANNISTER AND ZAYNA KAYHAT

Public initiative (MSLC) versus private initiative (MaRS):

SB: The success of the MLSC has come from securing private sector support very quickly, both for programs and investment. We came from different starting points but have reached a similar situation.

ZK: In Toronto we didn't have as clear a view of where we wanted to go as Boston did. But Canada is a very large country where no one has everything and we have a well-established culture of collaboration. Looking at our economy, it was clear that we needed a new economic force to replace traditional sectors. And even though we haven't had a visionary governor, like in Massachusetts, some members of our government were clearly behind the healthcare sector.

Advice:

SB: Even if it is a public initiative, non-governmental sources of funding are key to broadening the scope of action and securing the commitment of the stakeholders in the programs.

ZK: You must encourage the creation of investment funds, venture capital that can take risks and dynamize the system.

SB: And from the very beginning, you have to measure the impact in terms of income generated, funds raised and new jobs created. Metrics are essential to our work and from the start we have to think about how we can show the value generated, the work done and the results obtained.

ZK: Set a big goal and align everyone involved to achieve it.

SB: Set a strategy that makes sense for your country and then make sure everything you do and every decision you make is done with intention and makes sense within this framework.

Does Catalonia need a Chief Scientist?

MEHRDAD HARIRI, *Canadian Science Policy Centre* *(CPSC), CEO & President (Canada)*

See his presentation

Large-scale social changes –climate change, sustainability, ageing, managing natural resources, etc.– have made science more and more important in top-level political negotiations. Large international forums, like the G-20, call for international collaboration on research to tackle challenges that are both global and multidisciplinary.

Nevertheless, the scientific community is not normally directly involved in policymaking. In general, *"Politicians are scientifically illiterate, and scientists know nothing about policy."* This gap, in many countries, has led to the creation of a Chief Scientific Advisor, or Chief Science Officer, with functions that are generally more closely tied to scientific policy.

In his presentation, Mehrdad Hariri went over several models that have been adopted in countries including the United Kingdom, New Zealand, Australia, Scotland and Quebec, following in the footsteps of the United States, which created this position in 1957, under Eisenhower, after the political and media shock resulting from the Soviet Union launching Sputnik.

The different examples discussed center on two models:

- Chief Science Officer (CSO), who is responsible for **developing the country's scientific capacity and government-funded science**
- Chief Scientific Advisor (CSA), who focuses on **providing independent scientific guidance for the Prime Minister and cabinet**.

A CSO is responsible for **policy for science** –a function that in Europe is normally integrated into or controlled directly by specific ministries– while the CSA focuses on **science for policy**, providing strategic information for decision-making in all areas of government.

Does Catalonia need a figure of this type? Hariri left the answer up to his audience, highlighting the need for **well-established goals** and **open dialogue among stakeholders**. ■

BioRegion Dialogues: Science

ANDREU MAS-COLELL, Barcelona Institute of Science and Technology (BIST), President (Catalonia) / JOSEP M. MARTORELL, Barcelona Supercomputing Center (BSC), Associate Director (Catalonia)

See the vido (In Catalan)

Where is science in Catalonia and where is it heading? Is 'strong' science the foundation of innovation? Which models can serve as guidelines? What are the challenges we face for the future?

AMC: Prudence dictates that we have a strong scientific foundation, because it isn't expensive in terms of the country's economy and evidence shows that large clusters with a lot of innovative technology spring up around universities. Stanford came before Silicon Valley.

JMM: It is irrelevant whether there is one or several universities at the core of a cluster –or ecosystem, if you prefer. What matters is quality. An innovative ecosystem has five key elements: knowledge, entrepreneurship (start-ups), private investment, talent and an active role of government. This final point is what we've been missing, on the side of knowledge. We have good universities, but their hands are tied by the administration, which hasn't implemented the reforms necessary to let them advance as quickly as they need to.

AMC: A lot can be learned from the United States, but we have to be strong-hearted because their system is very different from ours. Canada is a closer match, they are more like us, but they have been able to learn from the Americans: Montreal and Toronto are good models. The talent-welcoming mechanisms in Amsterdam are also very interesting. They don't only focus on the researcher. They include their whole family, for example helping partners find work as well. What we have to learn from the clusters of the world is that they are not small. We have to worry about economies of scale –getting bigger, because we're at a critical point in terms of size– and what the Americans call the economy of scope: not being overly specialized. A good cluster needs tentacles, diversity, to be multidisciplinary.

In Catalonia, prioritizing research, once we had the university system in place, was a political decision. We wanted an open model working in a virtuous cycle: putting some money into attracting talent, which later would be able to attract more money. I think the results show this was a good choice.

JMM: Yes, and what happened after was that the model was maintained despite the negative environment, despite the difficulties, because many times it wasn't understood that public institutions need different management and direction models. We've opted for highly interventionist models, very conservative, instead of trusting more in those executing the plan, giving them the freedom they need and establishing a good accountability system.

AMC: Yes, we've seen ridiculous stories like the auditor that scolded a scientist because they had only proven three of the four hypotheses posed when drafting the project.

JMM: Science is far from power –maybe this is why no one has asked whether Rajoy's new government will include a Ministry of Science. We don't have to be dramatic about it, but it would be helpful to have more contact between scientists and politicians. And scientists have to take the first step.

Another topic that is always up for debate is whether we generate too many PhDs, which the research system can't absorb. This is a false issue, because all of the statistics show that PhDs have better access to the job market and, in an open system like ours, many of the 2,000 PhDs that graduate from Catalan universities each year are foreign students who don't stay here, but do enrich our ecosystem and forge international bonds with our researchers.

AMC: The great challenges facing science are global and well-known: climate change, sustainability, energy, etc. There is another series of challenges associated with the organization of science that make us wonder, on an international level, if size matters. We thought we had to compete with the US, but now we've realized that we're competing with China, for example in supercomputing. Europe is trying to address this challenge through a network, PRACE, instead of a single machine. But this makes decision-making a long and complex process and makes it difficult to compete.

JMM: I'm not sure if size matters, but if it does they'll catch up to us. China's supercomputing capacity is already 10 times greater than that of the US. It is also important to note that the way science is being done (based on juxtaposing small groups with a head researcher) is moving towards more complex models, like big science done with a supercomputer. However, while China, Japan and the US already have a roadmap of where they want to be in terms of supercomputing 10 years from now, Europe is just now thinking about it and we have some very clear roadblocks. These include highly restrictive EU regulations on public-private partnerships and the traditional difficulties France and Germany have understanding each other.

AMC: Yes, Europe is facing many challenges in terms of computing, things like Brexit don't help. Really, I don't think Brexit will have a big impact, but I think it really is a pity as it is impoverishing the European Union. We're losing 20% of our GDP, a huge financial center and some of the top universities in Europe. This is why negotiations should seek to reach deals to keep things as close as possible to the current situation.

JMM: Thinking about the future, I believe it is important to highlight that we have overcome the old debates, like the gap between basic science and applied science, and the feeling of being shunned, 15 years ago, when you spoke about creating start-ups, patents and transferring knowledge to the market. However, it is as true today as it was before that **the best way to defend science is to do science of excellence**. ■