OLD BONDS AND ELEMENTAL CONNECTIONS

Alberto Amo and
Jacqueline Bloch of
Laboratory of Photonics
and Nanostructures
perform an optical
experiment as part of the
CNRS work on polaritons.

Researchers in Paris and Tokyo are connected, but the two capitals have quite different patterns of collaboration.

BY TIM HORNYAK AND
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While international collaboration networks have become the hallmark of science, a large portion of top research is still produced by groups in the same city or neighbourhood. Analysis of papers included in the Nature Index reveals cities with a high number of local partnerships.

Taken at face value, the data indicate that Paris is the intra-city collaboration champion in 2015, forming 1,932 partnerships, followed by Tokyo, with 925 partnerships. In this context a partnership is between two universities or research organizations that have authors on papers in any of the 68 top natural science journals included in the index.

But, in the case of Paris, the numbers don't tell the full story.

PARIS

The top partnership in Paris last year was between Paris Diderot University and the Pierre and Marie Curie University (UPMC), exploiting their mutual strength in physical sciences. Researchers from both universities were part of the team that observed gravitational waves, published in a landmark *Physical Review Letters* paper this year.

The connection between these institutions is historic. Until 1968, both were part of the University of Paris (the Sorbonne), which was then the only university in the French capital. But, after a series of student and worker protests and calls for reform in May of that year, the government took steps intended to quell the political fervour. One move was to break the Sorbonne up into 13 autonomous universities. Despite the split, Paris Diderot University, known as Paris 7, and the UPMC, Paris 6, continued to share a campus until 1996.

Olivier Pironneau, professor emeritus of applied mathematics at UPMC, says part of the

legacy of that era is that collaborations among those at the 13 institutions tracing back to the Sorbonne arise more or less naturally. The centuries-old bonds between these centres of scholarship were not completely dissolved by the government's restructuring.

When Diderot and UPMC went their separate ways, Pironneau recalls that there was a heated argument over where the library should be located. The compromise was that books would go to Diderot, and periodicals would be kept at UPMC, a situation that continues to this day. "It doesn't make much sense," says Pironneau. "But periodicals can now be consulted online, so it doesn't much matter."

In the index, UPMC was a partner in five of Paris' ten strongest collaborations, measured by the size of joint contributions to articles in 2015, and was followed by Paris Diderot University.

Public research institutes such as the Atomic Energy and Alternative Energies Commission (CEA) and the French National Institute for Health and Medical Research (INSERM) were also members of many of the city's top collaborations. Both organizations seek to forge close partnerships with other public and private research institutions. In the case of INSERM, all its researchers are embedded in French universities or hospitals, while the CEA has dozens of research units with its partners.

Recent administrations have gone a step beyond just encouraging collaboration between institutions, going as far as suggesting some universities should merge to achieve a critical mass. UPMC and Paris-Sorbonne University will merge by 2018, although remain on their own campuses.

University presidents have also directed researchers to join forces to boost France's poor track record in academic rankings, such as the Shanghai Academic Ranking of World

PARIS

WHAT'S ON THE MAP

Circles show an institution's contribution to journals in the index, a measure known as **fractional count (FC)**. Lines denote collaborations between pairs of institutions in the Paris metropolitan area on papers included in the index. Line thickness represents the strength of a collaboration between two institutions, which is measured by bilateral **collaboration score**. The city's top 50 collaborations are shown on the map. In cases where universities have multiple campuses, the total contribution of those institutions is mapped to the primary campus. Read more about index metrics on page S32.

LEGEND

Fractional count (FC)

Strength of collaboration

Universities, says Pironneau. “Not that this has made much difference so far,” he says. Only three French universities made the top 100 ranking this year, two in the top 50.

POLICY INFLUENCE

One explanation for the plethora of collaborations in Paris is the country’s focus on research projects that combine multiple disciplines, a trend that has increased over the past 15 or 20 years, under the direction of both centre-left and centre-right governments.

Bernard Meunier, the president of the French Academy of Sciences, says this focus on multidisciplinary encourages researchers to join forces to increase their chances of being awarded funding. “Of course we need multidisciplinary research, provided that it is driven by research and not the opportunistic creation of artificial clusters in order to obtain funds,” he says.

Meunier also says that scientists report it is now extremely difficult to obtain research funding without creating a consortium of teams. “There are often three, four or even more teams involved in projects in the life sciences,” he says. Policies that encourage multidisciplinary result in each individual team getting less money than they would like to do their research. “The cash is so thinly spread that the researchers are happy to have some of it, but are unhappy that the amount is so limited,” he adds.

While collaborations amongst groups from different disciplines are encouraged in other countries, Meunier maintains that France is an extreme case. “Nowhere has the change been more marked than here,” he says.

Meunier argues that the shift has now gone too far, with the French National Research Agency (Agence Nationale de la Recherche, ANR) now usually rejecting original ideas from a single team. This is a particular problem for

senior researchers, who cannot reply on special funding schemes like those for early-career researchers. The ANR declined to comment on Meunier’s view.

Meunier would like France to emulate the European Research Council’s (ERC’s) practice of granting funds to principal investigators (PI), who then form their own teams from different disciplines as appropriate, which would make the process more efficient. “If 500 million euros a year were awarded to PIs for basic research in

France, that would be quite a different matter and would give French scientists hope for the future,” he says.

Most public research in France is supported by the government through universities and major agencies such as the CNRS, INSERM and INRA, which cover lab operating costs and salaries. The National Research Agency (Agence Nationale de la Recherche, ANR) funds competitive grants for basic and applied research.

Last year the ANR’s budget was €528.1 million, down from €553.7 million in 2014. Money also comes from the European Research Council and industry grants.

The government’s junior minister for higher education and research, Thierry Mandon, acknowledges that the process of applying for research funding needs simplification. He has introduced a first series of 50 simplification measures. Meunier welcomes this initiative, but is sceptical about the difference it will make. “France has an amazing capacity to resist simplification,” he says.

930

Contribution of institutions in Paris to index, measured by FC, in 2015.

323

Institutions involved in intra-city partnerships, Paris, 2015.

Top 50 partnerships shown on map.

Partnerships between pairs of institutions in Paris have increased over time.

TOKYO

In 2011, a team of Tokyo scientists made a startling discovery that had huge economic potential. Across vast stretches of the Pacific Ocean seafloor, they found clusters of the rare-Earth elements needed to manufacture high-tech devices such as lasers, compact fluorescent light bulbs, medical equipment and smartphones.

Five years later, the researchers from the University of Tokyo, the Tokyo Institute of Technology and the Japan Agency for Marine–Earth Science and Technology (JAMSTEC) are still working together and publishing papers. They recently uncovered the conditions that help form these hotspots of rare-Earth elements.

When it comes to forming successful research

The vessel MIRAI on a voyage across the Pacific Ocean, where researchers found hotspots of the rare-Earth elements needed to make almost all high-tech devices.

UNIVERSITY OF TOKYO/JAMSTEC

TOKYO

WHAT'S ON THE MAP

Circles show an institution's contribution to journals in the index, a measure known as **fractional count (FC)**. Lines denote collaborations between pairs of institutions in the Tokyo metropolitan area on papers included in the index. Line thickness represents the strength of a collaboration between two institutions, which is measured by bilateral **collaboration score**. The city's top 50 collaborations are shown on the map. With the exception of RIKEN, if universities have multiple campuses, the total contribution of those institutions is mapped to the primary campus. Read more about index metrics on page S32.

LEGEND

Fractional count (FC)

Strength of collaboration

Yasuhiro Kato, of the University of Tokyo University's Frontier Research Center for Energy, who leads the rare-Earth minerals team.

"FACE-TO-FACE DISCUSSION IS MUCH MORE INFORMATIVE AND INTERACTIVE THAN EMAIL."

partnerships, Tokyo is also a hotspot. There were 925 partnerships between two Tokyo institutions in 2015 — second in the index only to Paris for intra-city scientific collaborations.

With a regional population of 37 million people, Tokyo — the world's most populous metropolitan area by many rankings — has the second highest number of organizations publishing in index journals, after Beijing. The contribution of those 201 institutions accounted for close to a third of the country's high-quality science last year. "The very concentrated city, Tokyo, plays an important role as a hub of scientific activities in Japan," says Earth scientist Hikaru Iwamori, a member of the rare-Earth minerals team from JAMSTEC.

The University of Tokyo, the country's highest ranked institution in the index, is the epicentre of that hub (see graphic). It was a partner in one out of every eight collaborations in Tokyo last year, including eight of the ten strongest partnerships. Its collaboration with the RIKEN Center for Emergent Matter Science was the city's most productive.

The university is part of several long-term programmes to foster innovation and new technologies with others, such as the 4 Universities Nano/Micro Fabrication Consortium, a project that began in 2008 to develop engineering and construction methods for objects that are smaller than 1 micrometre. The consortium, which receives funding and cooperation from national and local governments, also involves some of Tokyo's other top institutions such as Tokyo Institute of Technology, ranked 7th in Japan, Keio University (12th) and Waseda University (17th) in 2015.

"Active collaborations among different universities in Tokyo can be attributed to the concentration of competent universities," says geologist Yasuhiro Kato, a professor in the University of Tokyo's Frontier Research Center for Energy and Resources who leads the rare-Earth

1,130

Contribution of institutions in Tokyo to index, measured by FC, in 2015.

155

Institutions involved in intra-city partnerships, Tokyo, 2015.

Top 50 partnerships shown on map.

Partnerships between pairs of institutions in Tokyo have increased over time.

minerals research team.

When Kato needed help decoding a massive collection of data on the chemical composition of nearly 4,000 samples of deep-sea sediments, he turned to Iwamori for his expertise in statistical analysis. "We know that there is a limit to what can be done by each researcher or a research group having similar knowledge and skills, and therefore believe we should actively collaborate with people who have what we lack," says Kato.

Using a statistical method called Independent Component Analysis (ICA), which was first used in neuroscience and information

science, Iwamori helped the team sift through the data. By combining Iwamori's analysis with the team's observations from individual samples, they concluded that a sufficiently slow sedimentation rate allowed the sea-floor to absorb rare-Earth minerals from seawater over 65 million years. "In collaborations, different techniques and ways of thinking can bring new and robust ideas," says Iwamori.

It also helps that Kato and Iwamori have been friends since they were classmates at the University of Tokyo more than three decades ago.

The pair still meet up, something Iwamori believes is important for successful collaborations. The rare-Earth minerals team met to examine their data using 3D rotating diagrams, which led to deeper interpretations of the results.

"Face-to-face discussion is different from email-based discussion. It is much more informative and interactive, and quicker perhaps," says Iwamori, who is also a visiting professor in Tokyo Institute of Technology's Department of Earth and Planetary Sciences.

Tokyo's high concentration of universities also means many conferences and symposiums are held in the city each year. Such a situation facilitates new encounters between scientists in different fields.

Once researchers get to know each other, their collaborations will last even after some of them move to other universities outside the city, says Kato. He recently started collaborating with microfossil expert Tetsuji Onoue from Kumamoto University, more than 900 kilometres south-west of Tokyo, after the two were introduced by a colleague.

Their work combined Onoue's skills identifying microfossils with Kato's chemical analysis expertise to study an extinction event in the Triassic. "It enables us to investigate one research subject much more multilaterally and comprehensively, and to propose the more interesting scientific story," says Kato. ■