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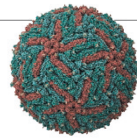

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Awkward first dates

Multiple dates for the anniversary of plate tectonics highlight the rolling nature of scientific discovery.

This week, the Geological Society in London will mark the 50th anniversary of plate tectonics — the theory that describes the workings of Earth, how earthquakes strike, and why volcanoes happen. Or will it?

The timing of the anniversary is disputed. After all, this journal published its own 50th anniversary commemoration of plate tectonics 4 years ago (*Nature* **501,** 27–29; 2013). Columbia University's Lamont–Doherty Earth Observatory in New York celebrated last May. Confused? Blame the rolling nature of scientific discovery. Plate tectonics did not spring into existence fully formed, Athena-like, on a particular day in a particular year.

No doubt aware of this, the London conference, although billing itself as "Plate Tectonics at 50", pins next week more cautiously: as a commemoration of the "advent of the paradigm" — the arrival of the model of the theory.

Coming up with the modern theory of Earth involved sparks of insight from many different researchers, working in different laboratories on different continents. Most of the resulting papers were published in the 1960s, many of them in *Nature*.

In September 1963, Frederick Vine and Drummond Matthews described how stripes of changing magnetism on the sea floor represented the spreading of new oceanic crust away from the ridge where it was born (F. J. Vine and D. H. Matthews *Nature* **199,** 947–949; 1963). This was the crucial insight that nailed the concept of sea-floor spreading, which had been hinted at in the 1950s, when oceanic mapping by Marie Tharp and Bruce Heezen revealed a mountainous rift, and so this is the paper that *Nature* editors choose to commemorate in plate-tectonics anniversaries. Fast-forward four years, and Dan McKenzie and Robert Parker publish the first complete description of how crustal plates move around on the surface of the sphere (D. McKenzie and R. L. Parker *Nature* **216,** 1276–1280; 1967), the paper that the Geological Society is now celebrating.

Of course, Vine, Matthews, McKenzie and Parker were far from alone. In the 1960s, plate tectonics was such a fecund, fast-moving field that it involved several instances of simultaneous discovery. In early 1967, as McKenzie was developing his ideas of rigid-plate motions, he looked at a conference abstract by colleague Jason Morgan and decided not to attend the talk. As it turns out, Morgan veered from the text of his abstract and instead described ideas of plate motions that were eerily like McKenzie's. Later that year, McKenzie sent off his manuscript to *Nature* — and, when he realized that Morgan was about to publish similar ideas, he asked the journal to delay his own paper in order to give Morgan the credit. *Nature*'s editor, John Maddox, sent a telegram back saying that the issue had already been typeset, so there would be no delay. Who has not skipped an event, only to have that affect their careers for years to come?

But back to the question of anniversaries. Popular interpretations of scientific history are biased towards the single great discovery by a single great person — and they are more easily commemorated in an anniversary. But most discoveries are much more nuanced and communal. Charles Darwin would not have published his ideas of evolution by natural selection when he did, had he not been prompted into it by the similar thoughts of Alfred Russel Wallace. Albert Einstein relied on the work of friends and colleagues to develop his general theory of relativity.

Similar broad revolutions are unfolding today. Despite all the bitterness and infighting over who invented the CRISPR–Cas9 gene-editing technique, the fact remains that a large number of very bright scientists made enormous advances quickly by playing off one another. Just as in the heyday of plate tectonics, one gene-editing breakthrough inspired the next, until biologists were brimming with publications. Historians may one day bicker about which CRISPR paper to celebrate on the 50th anniversary of the technique, but science as a whole is much better off than it was before.

> ***"A number of very bright scientists made enormous advances quickly."***

And so, we could celebrate a 1963 publication on the magnetism of the sea floor, or a 1967 paper on the geometry of spherical rotations, or even the entirety of the dawning of plate tectonics. But when was that? Was it in 1912, when Alfred Wegener came up with the idea of continental drift? Or was it decades later, when his ideas were finally transformed into the concept we now know as tectonics? Much of that delay might trace to US researchers viciously opposing his ideas, as historian Naomi Oreskes described in *Plate Tectonics* (Westview Press, 2001). But after the slow start, Earth scientists in the 1960s were quick to embrace the data and theories that redrew almost every aspect of their field.

Such is the nature of discovery — incremental at times, fast-paced at others, occasionally derailing into pettiness. But it does nearly always move in the right direction. In these times of political uncertainty and global unrest, that is an accomplishment worth noting. ■

Open science

International mobility and collaboration are linked to stronger research.

Some US biotechnology labs have responded to President Donald Trump's attempts to restrict immigration by releasing contrasting group photographs showing what less-open international borders would do to their workforces. A first image typically shows everyone who works in the lab. A second image includes only those who are permanent US residents, then just US citizens, and then only those who were born in the United States and whose parents also were (see, for example, go.nature.com/2ft02xj). The shrinkage from the first to the last image is striking — in some cases, about two-thirds of staff are lost. This reflects a widespread reality in research. A 2012 analysis showed that more than 60% of postdocs in the United States grew up overseas (see *Nature* **490,** 326–329; 2012).

When it comes to co-authorship, researchers in Europe are the most international. In 1981, only about one in six papers by a European scientist included co-authors from a different country. By 2011, that had risen to one in two. Papers with authors from more than one country also tend to be more highly cited (J. Adams *Nature* **497,** 557–560; 2013) .

This week, *Nature*'s Comment section publishes two bibliometric analyses that suggest international mobility has similar science-boosting effects.

The first (page 29) finds that researchers build strong links between nations as they travel around the world. The authors track 16 million individuals who published papers in 2008–15. Only about 4% of these people changed countries, but those who did had 40% higher average citation rates than those publishing solely in one region, a trend that held true across 13 regions. Importantly, mobile scientists retained ties in the countries they left.

The second (page 32) argues that countries with mobile scientific workforces produce papers that are more highly cited. (These are the same countries that have the greatest fraction of internationally authored papers.) The analysis shows that a nation's willingness to let scientists cross borders was a better predictor of highly cited papers than was the proportion of its gross domestic product that it spent on research.

These are complex issues. Citation rates are not necessarily a sign of quality, influence or long-term importance. And many confounding factors hamper attempts to link policies to impact. Still, such studies are necessary to provide evidence for policies on how to best support the scientific system.

The benefits of international movement are not entirely clear-cut. Leading scientists who change institutional affiliation (but not country) seem to boost both output and impact (G. Halevi *et al. Publ. Res. Q.* **32,** 22–37; 2016). Further work could reveal whether international papers — or more-open countries — prompt more innovative or worthy science. Details of the relative benefits of collaboration, or how the effects of an international move are mediated by discipline or career stage, must be teased out. So must the effects of particular policies, such as the ease with which potential trainees and working scientists acquire visas or other travel support.

"Existing scientific powerhouses are not destined to stand forever."

There is a bigger question: does the flow of leading scientists into a country bring tangible benefits for the citizens whose taxes fund their work? What about when one country's funds flow to a scientist's international collaborators? Evidence from patents and technological advances suggests that such investment is rewarded. But attention must be paid to ensure that a nation's connection to elite international scientists also supports work on local interests and needs.

Meanwhile, the scientific powerhouses of the United States and the United Kingdom seem determined to close their doors. US travel restrictions put in place last week tell working scientists from eight countries to stay away. And Britain's departure from the European Union puts scientific collaboration and access to European funds at serious risk.

Many nations with more-welcoming attitudes are poised to benefit. One long-term trend is clear: existing scientific powerhouses are not destined to stand forever. The picture can change — and quickly. ■

Hot hub

Europe's Joint Research Centre is doing well, but must think bigger.

The European Union's Joint Research Centre (JRC) uses the label EU Science Hub now. Whether the rebranding will increase its profile is one question. What science gets done inside this hub is another. In response to that query, there is some positive news. It is doing what it should be, and doing it well: collecting scientific and technical evidence in support of EU policies. That's according to the report of an external evaluation released this week (see go.nature.com/2kk2oeq). Furthermore, EU research commissioner Carlos Moedas praised the JRC at its annual public meeting on 26 September for contributing to the interminable struggle to counter false information and communicate science effectively to a sceptical public.

The JRC employs more than 2,000 scientists, who generate or collate a constant feed of information for authorities and politicians. In theory, this helps to support evidence-based policies — from the old chestnuts of genetically modified (GM) crops and nuclear safety to the ongoing refugee crisis, for which it holds a repository of relevant information and reliable statistics. Yet most of this work fails to reach public attention. For example, staff in the JRC transport section had worked out and published evidence that car makers were manipulating diesel-emission data years before the public scandal over Volkswagen finally broke in 2015.

The JRC celebrates its 60th anniversary this year. It has become a complex beast, operating at six sites in five EU countries, with a budget this year of €372 million (US$437 million). It was originally set up as a nuclear research organization, but widened its remit over the decades, adding institutes. Twenty years ago, it morphed into a centre with an explicit mission to provide support for a wide range of EU policies. But by that time it had lost its way, and tough reforms were introduced. A 2009 evaluation led by former UK government science adviser David King concluded that it was carrying out its new remit well, but criticized it for doing too little independent research of the type required to attract and keep the best scientists.

The new report, headed by the former Irish government science adviser Patrick Cunningham, echoes this call. It acknowledges how rapidly the centre has broken out of its much-criticized institute-based silos to restructure thematically into cross-site departments, such as energy and health, which more directly mirror policy areas. It also notes that the JRC has significantly increased its presence in the world's top-cited literature. But it says that the centre still does too little exploratory research — such research engages only 3.5% of JRC staff, well below the target of 10% that it set itself in 2015.

Why has it struggled? Although it has established partnerships with European universities and research institutes, and aided the exchange of scientists, many JRC researchers have different motivations from those of colleagues in universities. There is much satisfaction in contributing to policies that influence the lives of people in the EU. But officials and staff must look again at their priorities. As well as keeping the JRC relevant, a wider focus on the cutting edge would allow it to flag up hot topics to policymakers earlier.

But what policymakers do with the information they receive from their science service is another matter entirely. EU policy on GM crops is notoriously weak — scientific evidence for their safety has failed to convince some countries, whose citizens viscerally reject the technology. And sometimes the EU's intrinsic political weakness can block the implementation of its science-based policies. After all, the European Commission and EU member states ignored the findings on diesel emissions, and acted only after regulators in the United States cracked down. ■