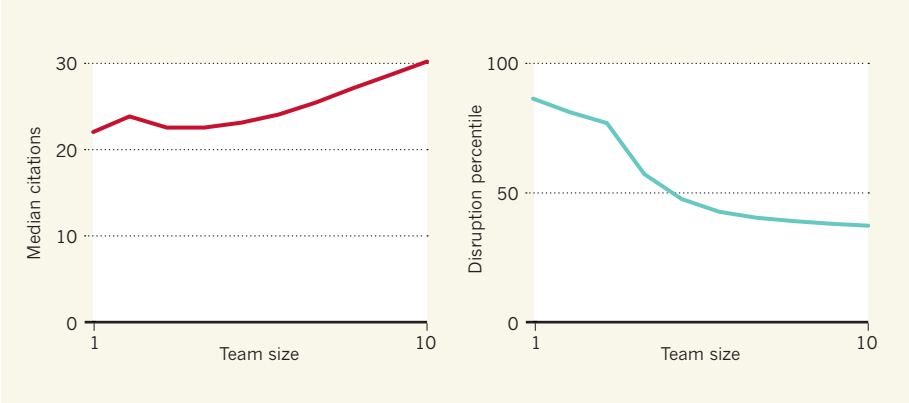

Figure 1 | Small teams make more-disruptive contributions to science than do large teams. Wu *et al.*[2] show that median citations to scientific articles (red curve) increase with team size, whereas articles' average disruption percentile (blue curve), as measured using a citation-based index[6], decreases as team size increases. This analysis is based on 24,174,022 research articles published in 1954–2014 and indexed on the Web of Science database. Similar associations were seen for patents and software-code snippets (not shown). (Adapted from ref. 2.)

difficult to compare scientists across fields or subfields.

Some new citation metrics have been proposed since the turn of the century, such as the *h* index[4] and the Relative Citation Ratio[5], but these alternatives have their own drawbacks. The *h* index is defined only for authors, not individual papers, and understates the impact of an author's most highly cited work. The Relative Citation Ratio normalizes an article's citations by a measurement of 'expected citations' given the article's field, but determining to which field an article belongs can be a subjective decision.

In this context, the article by Wu and colleagues comes as a breath of fresh air. The authors describe and validate a citation-based index of 'disruptiveness' that has previously been proposed for patents[6]. The intuition behind the index is straightforward: when the papers that cite a given article also reference a substantial proportion of that article's references, then the article can be seen as consolidating its scientific domain. When the converse is true — that is, when future citations to the article do not also acknowledge the article's own intellectual forebears — the article can be seen as disrupting its domain.

The disruptiveness index reflects a characteristic of the article's underlying content that is clearly distinguishable from impact as conventionally captured by overall citation counts. For instance, the index finds that papers that directly contribute to Nobel prizes tend to exhibit high levels of disruptiveness, whereas, at the other extreme, review articles tend to consolidate their fields.

Armed with this new measure, Wu *et al.* document a robust and striking empirical fact: the type of work performed by large teams and small teams differs markedly, with small teams being much more likely than large teams to publish disruptive articles (Fig. 1). This finding holds for articles, patents and computer-code snippets deposited on the web-based hosting service GitHub. It holds across all quantiles of the citation distribution. In the case of articles, it also holds across scientific disciplines, from biology to the physical sciences, as well as the social sciences.

A sceptic could object that large and small teams might differ in unobserved ways that are correlated with disruptive potential. In particular, scientists who prefer to work in small teams might be predisposed to upset the intellectual apple cart in their domains. Strikingly, however, the relationship documented by Wu *et al.* also holds within the corpus of work of individual scientists. The authors' analysis of a large sample of approximately 38 million name-disambiguated scholars and their published works shows that the same individual scientists participate in more consolidating projects when they operate in large teams than when they work in small teams.

These results are important in three respects. First, they provide us with a new, validated metric with which to evaluate the impact of policies or interventions that might affect the rate and direction of scientific progress, such as new funding mechanisms.

Second, they are a corrective to the zeitgeist that tends to view collaborations — across laboratories and especially across disciplines — as an inexorable trend that science funders should embrace and celebrate. Wu *et al.* invite us to recognize that sustained scientific progress requires both radical and incremental contributions, and that the investigations that lead to these contributions are probably better carried out by different types of team.

Third, the results show that researchers need not choose between a slavish devotion to citation metrics and ignoring citation data altogether. Rather, scientists should support the development of more-informative metrics and be careful about how these are interpreted and used.

As is the case with any new metric, the

50 Years Ago

Populations of red kangaroos that suffered badly in the Australian droughts of 1965–67 now seem to be increasing again. By 1967 there were so few in north-western New South Wales that the Division of Wildlife Research of the Commonwealth Scientific and Industrial Research Organization had to stop regular sampling of the population. When in March that year heavy rain produced the best growth of pasture for many years, an aerial survey showed that, despite the abundance of food, numbers of kangaroos had not been increased, as on previous occasions, by immigrants from surrounding areas. The density of kangaroos in this part of New South Wales was then the smallest since surveying began in 1964. But happily, after more rain in 1967, red kangaroos began breeding again and the population had begun to recover by March 1968.
From *Nature* 22 February 1969

100 Years Ago

Within the limits of a short article it is not possible to do justice to our feathered friends. The services rendered by homing-pigeons to the Army, Navy, and Air Forces have been invaluable, and numerous stories of their gallantry and devotion, under fire and even when wounded, have already appeared in the daily newspapers. Canaries, long recognised as the miners' friends in detecting the presence of poisonous underground gases, have played their part in the war by being used in the trenches and dug-outs when the presence of German poison-gas was suspected. It is not so generally known that parrots, in the earlier days of the war, were employed on the Eiffel Tower to give warning of the approach of enemy aircraft. Sea-gulls, on more than one occasion, betrayed the presence of submarines and mines and thus prevented disaster to our sailors.
From *Nature* 20 February 1919