Clarivate
Web of Science™

Highly Cited Researchers 2020

Pioneers in their fields.
Recognized by their peers.
Applauded by the world.

Clarivate™ Highly Cited Researchers™ have demonstrated significant and broad influence reflected in their publication of multiple highly cited papers over the last decade.

These highly cited papers rank in the top 1% by citations for a field or fields and publication year in the Web of Science™.

Of the world's population of scientists and social scientists, Highly Cited Researchers are 1 in 1,000.

Overview

The list of Highly Cited Researchers 2020 from Clarivate identifies scientists and social scientists who have demonstrated significant and broad influence, reflected in the publication of multiple papers frequently cited by their peers during the last decade.

Researchers are selected for their exceptional influence and performance in one or more of 21 fields (those used in Essential Science Indicators™ or ESI) or across several fields.

6,389 researchers are named Highly Cited Researchers in 2020 – 3,896 in specific fields and 2,493 for cross-field performance. This is the third year that we have identified researchers with cross-field impact.

The number of researchers selected in each field is based on the square root of the population of authors listed on the field's highly cited papers. The number of those with cross-field influence is determined by finding those who have influence equivalent to those identified in the 21 fields.

For the Highly Cited Researchers 2020 analysis, the papers surveyed were the most recent papers available to us – those published and cited during 2009 to 2019 and which at the end of 2019 ranked in the top 1% by citations for their ESI field and year (the definition of a highly cited paper).

The threshold number of highly cited papers for selection differs by field, with Clinical Medicine requiring the most and Economics and Business the fewest.

A second criterion for selection is a citation count to highly cited papers that ranks the individual in the top 1% by total citations in an ESI field for the period surveyed.

There is no unique or universally agreed concept of what constitutes extraordinary research performance

To identify researchers with cross-field impact, highly cited paper and citation counts are normalized through fractional counting according to the thresholds required for each field (thus, each Clinical Medicine paper has a smaller unit fraction, or counts less, than one in Economics and Business). Citation counts are treated in a similar manner. If the sum of the fractional publication counts and the sum of the fractional citation counts for a researcher equals 1.0 or more, the individual exhibits influence equivalent to a researcher selected in one or more ESI-defined fields and is therefore selected as a Highly Cited Researcher for exceptional cross-field performance.

There is no unique or universally agreed concept of what constitutes extraordinary research performance and elite status in the sciences and social sciences. Consequently, no quantitative indicators will produce a list that satisfies all expectations or requirements. Moreover, a different basis or formula for selection would generate a different – though likely overlapping – list of names. Thus, the absence of a name on our list cannot be interpreted as inferior performance or stature in comparison to those selected. To understand both the meaning and the inevitable limitations of our analytical approach, a careful reading of the methodology is required.

"Highly Cited Researchers wield a vastly disproportionate influence on their fields."[1]

John N. Parker (US National Science Foundation and Arizona State University), Christopher Lortie (York University), and Stefano Allesina (University of Chicago)

[1] John N. Parker, Christopher Lortie, Stefano Allesina, "Characterizing a scientific elite: The social characteristics of the most highly cited scientists in environmental science and ecology," *Scientometrics*, 85 (1): 129-143, October 2010. DOI: 10.1007/s11192-010-0234-4

Who would contest that in the race for knowledge it is human capital that is fundamental?

Talent – including intelligence, creativity, ambition and social competence – outpaces other capacities such as access to funding and facilities, although these are typically also needed for success.

Recognition and support of the scientific elite, both fully formed and incipient, is important for a nation or an institution's plans for efficient and accelerated advancement.

The Highly Cited Researchers 2020 list from Clarivate helps identify that small fraction of the researcher population that contributes disproportionately to extending the frontiers of knowledge and gaining for society innovations that make the world healthier, richer, more sustainable and more secure.

Citations: Pellets of peer recognition

Eugene Garfield
Founder of the Institute for Scientific Information (ISI), pioneer in the field of scientometrics

When Eugene Garfield produced the first Science Citation Index in 1964, he did so to make searching the literature more efficient and effective. He called his creation an "association-of-ideas index."[2] The connections he captured between topics, concepts or methods discussed in indexed papers could be trusted, he argued, because they were based on the informed judgments of researchers themselves, as recorded in the references they appended to their papers.

Thus, the network of citations linking items in the Web of Science offers a cognitive road map for those seeking to follow the progression of a finding or advancement – a map sometimes leading to unexpected regions that can turn research in a new, promising direction.

The raison d'être of the Web of Science is and always has been to help researchers find the information they need to carry out their investigations. And today Clarivate continues Garfield's work by providing trusted insights and analytics to enable researchers to accelerate discovery.

A secondary use of a citation index for science evolved in the decade after its introduction: analysis of research performance. Citations, when tallied and especially at high frequency, reveal influence and utility (determining importance and quality, however, requires expert judgment). In 1972, the U.S. National Science Foundation included publication and citation data in its first *Science Indicators* report, which permitted comparisons of national research activity, focus, performance and growth. In the 1980s, and in Europe particularly, publication and citation data were harvested and deployed for analysis of universities' research performance.

New Public Management, introduced in universities in the United States, the United Kingdom and Australia in the 1980s and 1990s, applied business management methods to academia and emphasized performance indicators and benchmarks. Academic scientists and social scientists, who previously rejected evaluation by outsiders and insisted on traditional peer review, have gradually accepted bibliometric assessments because opportunities and rewards tied to such assessments have become institutionalized. Some researchers now list citation data on their CVs and websites, such as a total citation count or an h-index.

[2] Eugene Garfield, "Citation indexes for science: A new dimension in documentation through association of ideas," *Science*, 122 (3159): 108-111, July 15, 1955. DOI: 10.1126/science.122.3159.108)

The practice of citing another researcher's work and the interpretation of citation statistics has been debated for many years.[3] Some assert that citations convey impact or popularity; others say they function largely as rhetorical devices and collectively create a socially constructed reality.

The late Robert K. Merton, the 20th century's leading sociologist of science, called the citation "a pellet of peer recognition."[4] Citations, he said, were repayments of an intellectual debt to others. He emphasized that citation was an essential part of normative behavior among researchers, that it was a considered, formal and obligatory activity, one that included a moral imperative to cite others when appropriate. It is largely this perspective that supports citation analysis to identify research influence. In most fields, there is a moderate positive correlation between peer esteem and citation frequency of papers and people, shown in a variety of so-called validation studies.

Evaluating the research performance of individuals is the most contentious application of publication and citation data. Apart from being an emotionally charged exercise, difficulties include finding comparable researchers or research publications to enable fair comparisons, expecting that influence and impact can be detected quickly when it may require many years, and selecting appropriate indicators, ones in alignment with the agreed priorities and values of a research program. A specific hazard is false precision – making distinctions without any meaningful differences – which frequently arises in dealing with small numbers so often encountered in analyzing the work of an individual rather than that of an institution or nation.

When, however, a researcher's record exhibits top-tier status quantitatively, demonstrated by the production of papers in the top 1%, top 0.1% or even top 0.01% of a citation distribution, one can be more certain of having positive and reliable evidence that the individual under review has contributed something of utility and influence. Having multiple contributions of this type increases confidence in attributing substantial influence to a researcher's oeuvre.

The raison d'être of the Web of Science is and always has been to help researchers find the information they need to carry out their investigations.

Still, the application of the data (or of the designation 'Highly Cited') – for example in the context of appointment or promotion decisions or in awarding research funds – demands informed interpretation.

This perspective is consistent with two of the recommendations of the Leiden Manifesto (2015): that "quantitative evaluation should support qualitative, expert assessment," and that "assessment of individual researchers [should be based] on a qualitative judgement of their portfolio."[5]

One should never rely on publication and citation data as a substitute for reading and assessing a researcher's publications – that is, for human judgment.

[3] Dag W. Aksnes, Liv Langfeldt, and Paul Wouters, "Citations, citation indicators, and research quality: An overview of basic concepts and theories," *Sage Open*, 9 (1): article number 2158244019829575, February 7, 2019. DOI: 10.1177/2158244019829575

[4] Robert K. Merton, "The Matthew Effect in science, II: Cumulative advantage and the symbolism of intellectual property," *Isis*, 79 (4): 606-623, December 1988. DOI: 10.1086/354848

[5] Diana Hicks, Paul Wouters, Ludo Waltman, Sarah de Rijcke, and Ismael Rafols, "The Leiden Manifesto for research metrics," *Nature*, 520 (7548), 429–431, April 23, 2015. DOI: 10.1038/520429a

Beyond questions of evaluation, Garfield was fascinated by the power of citations to discriminate the typical from the truly exceptional researcher. The power-law nature of the citation distribution allows one to rapidly focus on a small number of top-end 'events,' both papers and people. Over the years he produced many lists of most-cited researchers in almost every field of inquiry. And he took special interest in using citation data to forecast Nobel laureates by identifying a group of researchers he termed 'of Nobel class.'[6]

The Highly Cited Researchers list extends Garfield's work in recognizing investigators whose citation records position them in the top strata of influence and impact. This year's list includes 26 Nobel laureates, including three announced this year: Emmanuelle Charpentier, Max Planck Unit for the Science of Pathogens, Berlin, Germany (Chemistry); Jennifer A. Doudna, University of California, Berkeley, United States (Chemistry); and, Reinhard Genzel, Max Planck Institute for Extraterrestrial Physics, Garching, Germany and University of California, Berkeley, United States (Physics).

Also included in this year's list of Highly Cited Researchers are 77 Citation Laureates: individuals recognized by Clarivate, through citation analysis, as 'of Nobel class' and potential Nobel Prize recipients.

Figure 1: Nobel laureates identified as Highly Cited Researchers 2020

Name	Category and year
James P. Allison	Physiology or Medicine 2018
David Baltimore	Physiology or Medicine 1975
Emmanuelle Charpentier	Chemistry 2020
Jennifer A. Doudna	Chemistry 2020
Esther Duflo	Economics 2019
Eugene Fama	Economics 2013
Ben L. Feringa	Chemistry 2016
Albert Fert	Physics 2007
Andre K. Geim	Physics 2010
Reinhard Genzel	Physics 2020
John B. Goodenough	Chemistry 2019
Theodor W. Hänsch	Physics 2005
James J. Heckman	Economics 2000
Alan J. Heeger	Chemistry 2000
Brian K. Kobilka	Chemistry 2012
Robert J. Lefkowitz	Chemistry 2012
Edvard I. Moser	Physiology or Medicine 2014
May-Britt Moser	Physiology or Medicine 2014
Konstantin Novoselov	Physics 2010
Gregg L. Semenza	Physiology or Medicine 2019
Phillip A. Sharp	Physiology or Medicine 1993
Fraser Stoddart	Chemistry 2016
Thomas C. Südhof	Physiology or Medicine 2013
Susumu Tonegawa	Physiology or Medicine 1987
†Roger Y. Tsien	Physiology or Medicine 2008
Shinya Yamanaka	Physiology of Medicine 2012

[6] Eugene Garfield and Alfred Welljams-Dorof, "Of Nobel class: A citation perspective on high-impact research authors," *Theoretical Medicine*, 13 (2): 117-135, June 1992. DOI: 10.1007/BF02163625

Highly Cited Researchers and 2020 Nobel Laureates

Emmanuelle Charpentier
2020 Nobel laureate in Chemistry

Jennifer A. Doudna
2020 Nobel laureate in Chemistry

Reinhard Genzel
2020 Nobel laureate in Physics

Emmanuelle Charpentier
2020 Nobel laureate in Chemistry

Emmanuelle Charpentier
Director and Scientific Member, Max Planck Unit for the Science of Pathogens

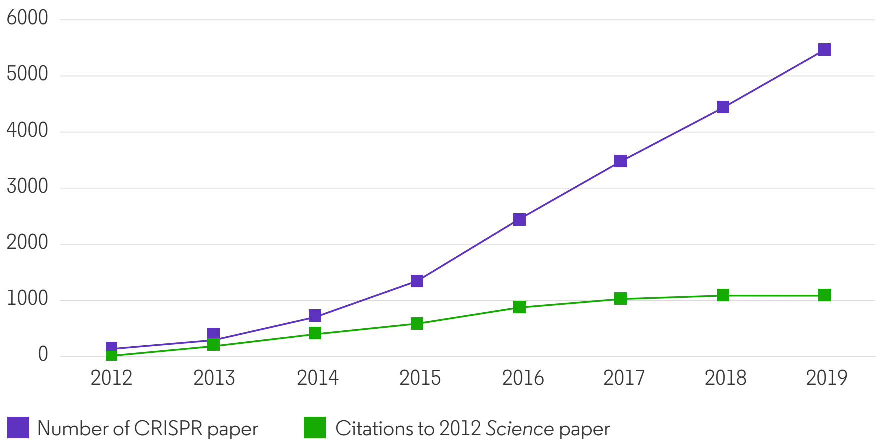
Photo credit: Hallbauer & Fioretti

The 2020 Nobel Prize for Chemistry was awarded to Emmanuelle Charpentier, Max Planck Unit for the Science of Pathogens, Berlin, and Jennifer A. Doudna, University of California, Berkeley, "for the development of a method for genome editing." Their CRISPR/Cas9 "genetic scissors" cuts DNA at a specific location and allows researchers to modify genes with precision. "This tool has contributed to many important discoveries in basic research, and plant researchers have been able to develop crops that withstand mould, pests and drought," reads the press release of the Royal Swedish Academy of Sciences. "In medicine, clinical trials of new cancer therapies are underway, and the dream of being able to cure inherited diseases is about to come true."[7]

Publication and citation data in the Web of Science reveals the CRISPR revolution – and how quickly it transformed the work of thousands of researchers. The chart shows the number of citations to the breakthrough paper of Charpentier, Doudna and colleagues, published in August 2012[8], which rose from 11 that year to more than 1,000 in recent years. Total citations now top 6,000, making this relatively recent report among the 1,000 most cited papers in the Web of Science and among the 100 most cited of the last decade. The chart also illustrates the growth of CRISPR-related papers each year from 2012 to 2019, which rocketed from 133 to 5,467, respectively. To date, more than 23,000 papers using the CRISPR method have been recorded in the Web of Science.

Nobel recognition for CRISPR and for Charpentier and Doudna came quickly and was generally expected. Both scientists were selected as Citation Laureates in 2015, conveying our view that a Nobel Prize was in prospect. Both Charpentier and Doudna have appeared regularly in Clarivate Highly Cited Researchers lists. It must be admitted, however, that citation analysis was not needed to forecast this Nobel, so obvious was the importance and impact of their achievement.

Figure 2: CRISPR revolution by papers and citations



[7] https://www.nobelprize.org/prizes/chemistry/2020/press-release/

[8] Martin Jinek, Krzysztof Chylinski, Ines Fonfara, Michael Hauer, Jennifer A. Doudna, Emmanuelle Charpentier, "A programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity," *Science*, 337 (6096): 816-21, August 17, 2012. DOI: 10.1126/science.1225829

Jennifer A. Doudna
2020 Nobel laureate in Chemistry

Jennifer A. Doudna
Professor of Chemistry, Professor of Biochemistry and Molecular Biology, Li Ka Shing Chancellor's Professor in Biomedical and Health, University of California, Berkeley

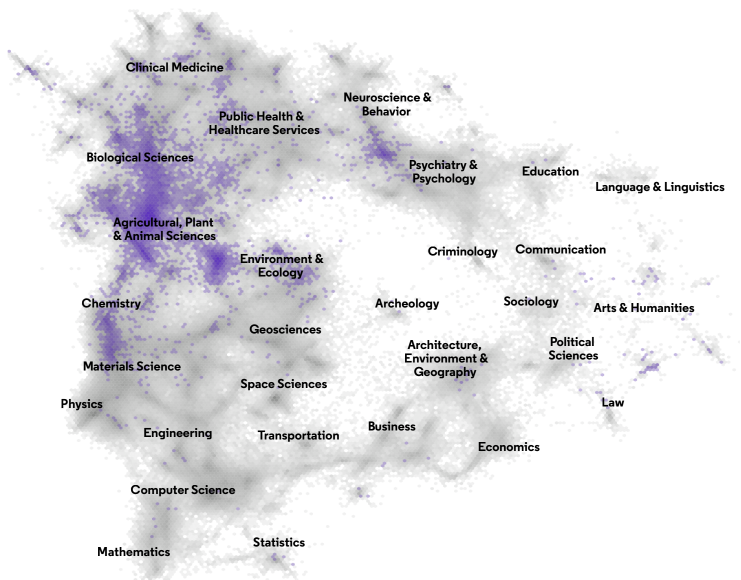
Photo credit: Duncan Hull

A robust citation record for a scientist frequently goes hand in hand with top international awards: both are indicators of peer esteem. From 2015 to this year, Doudna and Charpentier collected almost every top prize in the life sciences, including several that prefigure selection for a Nobel Prize. Among these are the Gruber Foundation International Prize in Genetics (2015), the Breakthrough Prize in the Life Sciences (2015), the Canada Gairdner International Award (2016), the Japan Prize (2017), the Albany Medical Center Prize (2017), the Harvey Prize (2018) and the Wolf Prize in Medicine (2020).

But citation analysis can reveal more than research performance and peer esteem. As Eugene Garfield emphasized when he introduced the concept of a citation index for the scientific literature, citations create a network of papers linked by related concepts, ideas and methods, a network that can be navigated profitably for information retrieval. More than this, a network of citations reveals a structure of research activity. In the accompanying figure, papers dealing with CRISPR indexed in the Web of Science from 2014 to 2019 are highlighted against a background of field categories, derived from journal-to-journal citation relationships. As expected, the bulk of CRISPR papers are found in the Biological Sciences and in Agricultural, Plant and Animal Sciences (on the left). However, CRISPR research is present in many other areas as well: Environment and Ecology, Chemistry, Neuroscience and Behavior, Psychiatry and Psychology, and even in Law (on the bottom right). The powerful CRISPR technique has prompted much discussion among researchers on the ethical limits of its use, most especially in germline editing, and Doudna has been at the forefront in advocating for education and responsible uses in the lab and in the clinic.[9]

The CRISPR revolution is not even 10 years old. Its continuing development and spread can and will be monitored through science mapping. Landscape maps of research activity, including clusters of related highly cited papers that we call research fronts, show not only the structure and dynamics of important specialty areas, but also reveal key players including nations, institutions and individuals.[10]

Figure 3: The CRISPR research front: highly cited CRISPR papers and their distribution across the scientific landscape



Source: Martin Szomszor, David Pendlebury, and Gordon Rogers. *Global Research Report: Research Fronts in the Web of Science: From Metrics to Meaning*. Institute for Scientific Information, Clarivate, London and Philadelphia, September 2020, pg 13.

[9] Jennifer Doudna, "CRISPR's unwanted anniversary," *Science*, 366 (6467): 777, November 15, 2019. DOI: 10.1126/science.aba1751

[10] Martin Szomszor, David Pendlebury, and Gordon Rogers. *Global Research Report: Research Fronts in the Web of Science: From Metrics to Meaning*. Institute for Scientific Information, Clarivate, London and Philadelphia, September 2020

Reinhard Genzel
2020 Nobel laureate in Physics

Reinhard Genzel
Director and Scientific Member, Max Planck Institute for Extraterrestrial Physics

Photo credit: Derek Henthorn / Max-Planck-Gesellschaft

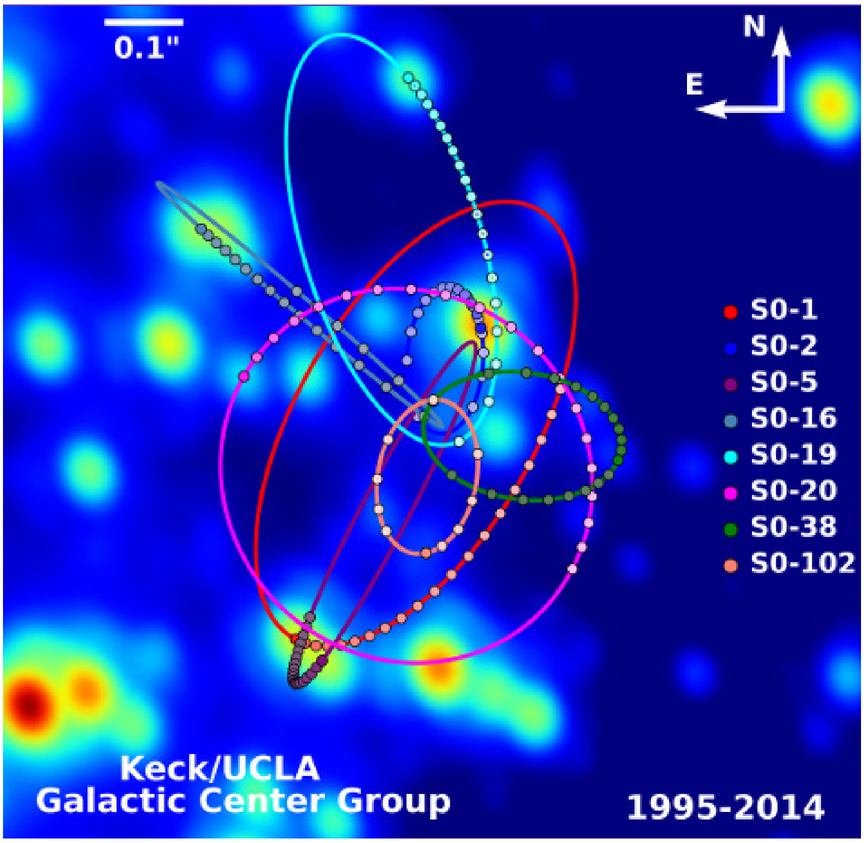
The 2020 Nobel Prize in Physics was awarded to Sir Roger Penrose, Oxford University, "for the discovery that black hole formation is a robust prediction of the general theory of relativity" and to Reinhard Genzel, Max Planck Institute for Extraterrestrial Physics, Garching, Germany and University of California, Berkeley, and to Andrea Ghez, University of California, Los Angeles, "for the discovery of a supermassive compact object at the centre of our galaxy." Penrose was recognized for research published in 1965[11] whereas Genzel and Ghez were honored for research pursued and published independently of one another during the 1990s and 2000s.

Penrose was named a Citation Laureate in 2008. Genzel appears this year as a Highly Cited Researcher in Space Science, as he has each year since 2014.

Most Nobel laureates have one or more papers cited 2,000 times or more. Genzel and Ghez exhibit a different citation profile but still one 'of Nobel class.' Both have published a series of highly cited papers over decades that cumulatively carries the same weight as a few citation blockbusters. Their research depended on developing and refining instrumentation over many years, and as more details of their observation of the stars orbiting Sagittarius A* were obtained, new reports were issued. These papers collected hundreds of citations each, until the next findings appeared. We should note that the selection method of Highly Cited Researchers is designed to recognize this pattern: publication of multiple highly cited papers.

Genzel published some two dozen highly cited papers during the period 2009 to 2019, including a 2010 review with 550 citations in *Reviews of Modern Physics*.[12]

Figure 4: Stars orbiting Sagittarius A*



Source: http://www.astro.ucla.edu/~ghezgroup/gc/blackhole.html

[11] Roger Penrose, "Gravitational collapse and space-time singularities." *Physical Review Letters.* 14 (3): 57–59, January 1965. DOI: 10.1103/PhysRevLett.14.57

[12] Reinhard Genzel, Frank Eisenhauer, and Stefan Gillessen, "The galactic center massive black hole and nuclear star cluster," *Reviews of Modern Physics*, 82 (4): 3121—3195, December 20, 2010. DOI: 10.1103/RevModPhys.82.3121

Highly Cited Researchers 2020

Highly Cited Researchers from Clarivate is an annual list recognizing influential researchers in the sciences and social sciences from around the world.

The 2020 list contains about 6,400 Highly Cited Researchers, some 3,900 in 21 fields of the sciences and social sciences and about 2,500 Highly Cited Researchers identified as having exceptional performance across several fields.* The list focuses on contemporary research achievement: only highly cited papers in science and social sciences journals indexed in the Web of Science Core Collection™ during the 11-year period 2009 to 2019 were surveyed. Highly cited papers are defined as those that rank in the top 1% by citations for field and publication year.

Using our InCites™ analytics tool, the data are derived from the ESI database, which reveals emerging science trends as well as influential individuals, institutions, papers, journals and countries. The fields are also those employed in ESI – 21 broad fields defined by sets of journals and exceptionally, in the case of multidisciplinary journals such as *Nature* and *Science,* by a paper-by-paper assignment to a field based on an analysis of the cited references in the papers. This percentile-based selection method removes the citation advantage of older papers relative to recently published ones, since papers are weighed against others in the same annual cohort.

Essential Science Indicators fields

- Agricultural Sciences
- Biology and Biochemistry
- Chemistry
- Clinical Medicine
- Computer Science
- Economics and Business
- Engineering
- Environment/Ecology
- Geosciences
- Immunology
- Materials Science
- Mathematics
- Microbiology
- Molecular Biology and Genetics
- Neuroscience and Behavior
- Pharmacology and Toxicology
- Physics
- Plant and Animal Sciences
- Psychiatry/Psychology
- Social Sciences
- Space Science

Researchers who, within an ESI-defined field, publish papers that are then highly cited by their peers are judged to be influential, so the production of multiple top 1% papers is interpreted as a mark of exceptional influence. Relatively young and early career researchers are more likely to emerge in such an analysis than in one dependent on total citations over many years.

* The number of unique Highly Cited Researchers is 6,167, including 3,896 in the ESI fields and 2,493 in the cross-field category. The analysis reported here is based on appearances of Highly Cited Researchers in specific fields, and a small number are selected in more than one ESI field.

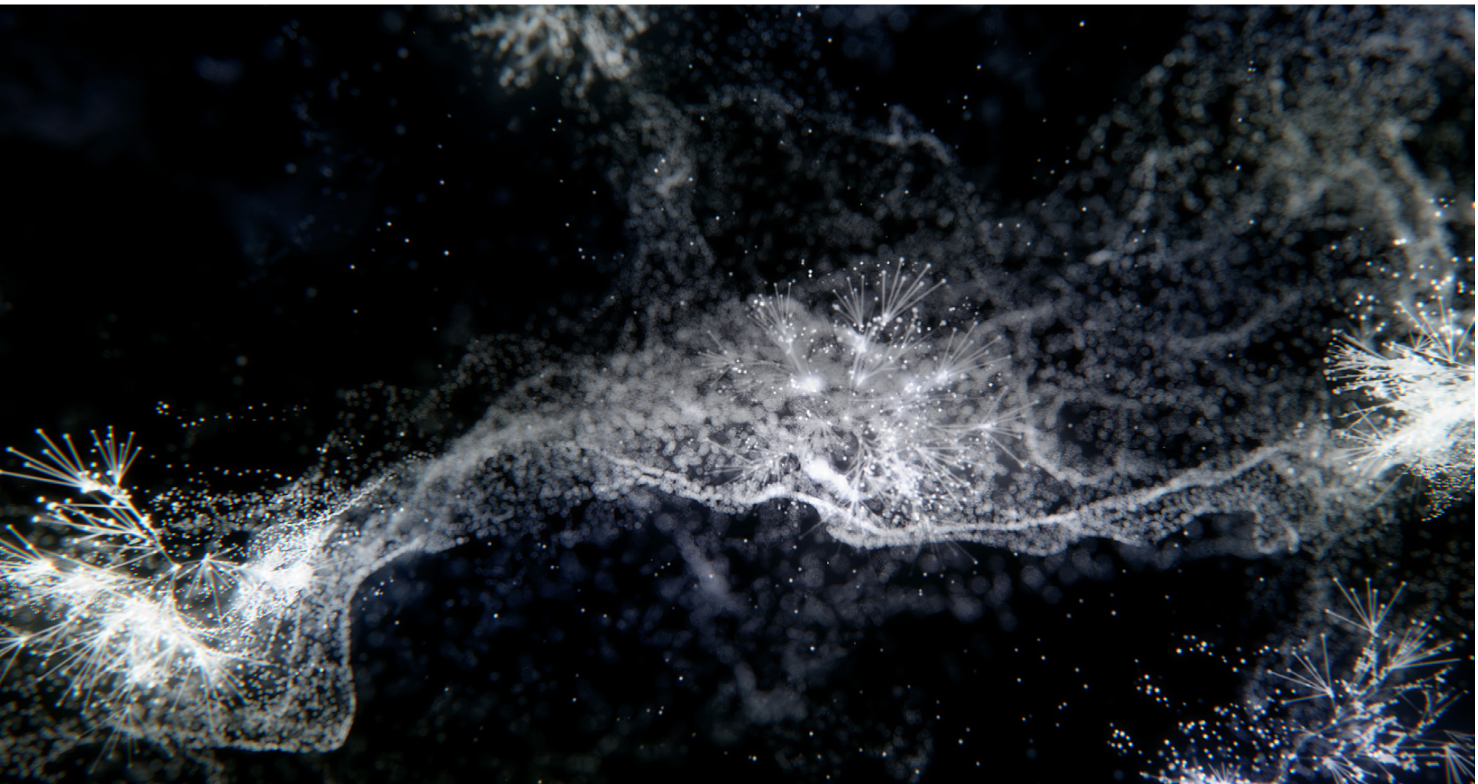
Recognizing early and midcareer as well as senior researchers is one of our goals in generating Highly Cited Researchers lists. The determination of how many researchers to include in the list for each field is based on the population of each field, as represented by the number of disambiguated author names on all highly cited papers in that field, 2009 to 2019. The ESI fields vary greatly in size, with Clinical Medicine being the largest in terms of highly cited papers and Space Science the smallest; likewise, Clinical Medicine is largest in terms of researchers whereas Mathematics is smallest. The square root of the number of authors in each field indicated how many individuals should be selected.

One of two criteria for selection is that the researcher must have enough citations to their highly cited papers to rank among all authors in the top 1% by total citations in the ESI field in which that person is considered. Authors of highly cited papers who meet this criterion in a field are ranked by number of such papers, and the threshold for inclusion is determined, as mentioned, using the square root of the population represented by the number of disambiguated authors names on the highly cited papers in a field. All who published highly cited papers at the threshold level are admitted to the list, even if the final list then exceeds the number given by the square root calculation.

In addition, and as a concession to the somewhat arbitrary cut-off, any researcher with one fewer highly cited paper than the threshold number is also admitted to the list if total citations to their highly cited papers rank that individual in the top 50% by total citations of those at the threshold level or higher. The justification for this adjustment is that it seems to work well in identifying influential researchers, in the judgment of the Web of Science citation analysts.

Of course, there are many highly accomplished and influential researchers who are not recognized by the method described above and whose names do not appear in the 2020 list. This outcome would hold no matter what specific method were chosen for selection. Each measure or set of indicators, whether total citations, h-index, relative citation impact, mean percentile score, etc., accentuates different types of performance and achievement. Here we confront what many expect from such lists but what is unobtainable: that there is some optimal or ultimate method of measuring performance.

The only reasonable approach to interpreting a list of top researchers such as ours is to fully understand the method behind the data and results, and why the method is used. With that knowledge, in the end, the results may be judged by readers as relevant or irrelevant to their needs or interests.

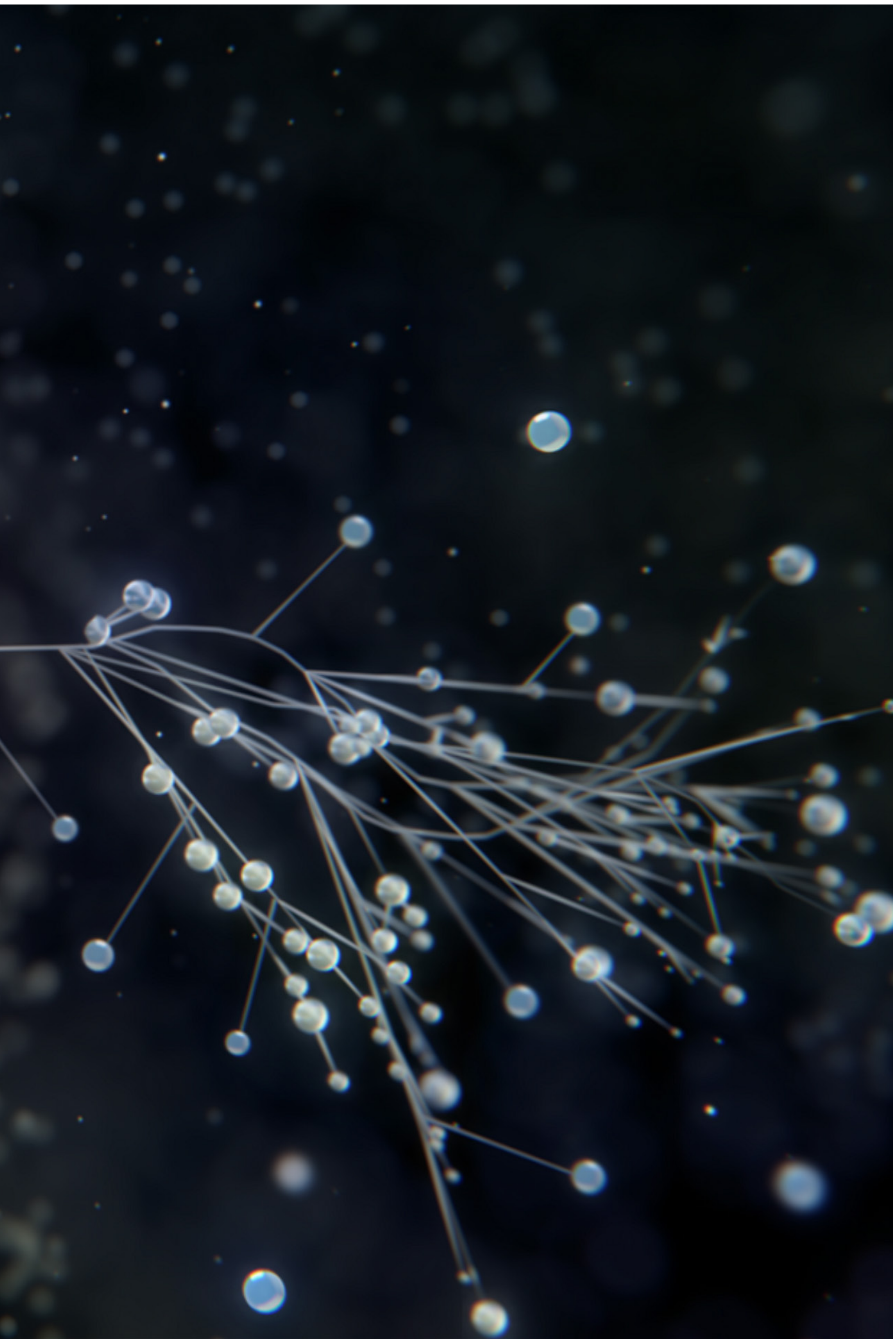


Researchers with cross-field impact

In 2018, for the first time, we introduced a new Highly Cited Researchers cross-field category to identify researchers with substantial influence across several fields during the data census period. As mentioned above, 2,493 researchers with cross-field impact now join some 3,896 who have been selected in one or more of 21 broad ESI fields. The addition of cross-field selectees yielded a substantial increase from those chosen in the 21 ESI fields only, but the current 6,389 still represent a very small fraction of all scientists and social scientists actively publishing today.

Since introducing Highly Cited Researchers in 2014, Clarivate analysts have received the suggestion from many that limiting the methodology for selection to only those with a required number of highly cited papers in a single field, as defined in ESI, discriminates against researchers who publish highly cited papers in several fields but not enough in any one field to be chosen.

We responded to this concern. In line with recommendations on best practice, we wanted to ensure that any metrics or analyses that we produce are structured and presented in a responsible manner. Extending the identification of Highly Cited Researchers to cross-disciplinary work fulfills that goal.



3,896

Highly Cited Researchers in specific field

2,493

Highly Cited Researchers for cross-field performance

Figure 5: Method for identifying Highly Cited Researchers in the cross-field category

ESI field	First name	Last name	Number of HCPs	Citation to HCPs	Field citation threshold	Field paper threshold	Field paper score	Field citation score
Field 3	Joseph	Savant	1	98	1857	22	0.045	0.053
Field 6	Joseph	Savant	7	2937	946	8	0.875	3.105
Field 14	Joseph	Savant	3	663	676	6	0.500	0.981
Field 16	Joseph	Savant	4	3397	2223	16	0.250	1.528
Cross-field	**Joseph**	**Savant**					**1.670**	**5.667**

The challenge for us was finding a method that took account of the different threshold number of highly cited papers in each field so that those contributing papers in several fields could be compared in an equal manner with those selected in one or more ESI fields. The solution chosen was to fractionally count the credit for each highly cited paper such that a paper in a field with a high threshold number of papers was weighted less than a paper in a field with a lower threshold number of papers. The example at the top of this page illustrates the method.

The fictional researcher Joseph Savant published 15 highly cited papers in four ESI fields. Seven papers in Field 6, with a threshold number of eight for selection, earned Savant a credit of 0.875 (or 7/8ths). Three papers in Field 14, with a threshold number of six for selection, were worth 0.5. The sum of the fractional paper counts in each field yielded a total cross-field paper score of 1.67. A score of 1 or more indicates that the individual achieved equivalent impact to a researcher chosen in a specific ESI field.

The second criterion for selection as a Highly Cited Researcher is enough citations from other researchers to rank in the top 1% by citations for a field. Again, citations in different fields were fractionated in a similar manner to the treatment of papers. In the example above, Professor Savant earned more than five times the number of citations needed for selection as an influential cross-field researcher. Both criteria had to be met for selection as a cross-field Highly Cited Researcher, just as required for selection in one or more ESI fields.

Traditional field definitions are useful in some contexts but less so in others. Today, an immunologist may identify himself as a biochemist and a molecular biologist. Another researcher may be hard pressed to say whether she is a chemist, materials scientist or engineer. Breaking through the artificial walls of conventional disciplinary categories helps to keep our Highly Cited Researcher list contemporary and relevant.

Moreover, as frontier areas of research are frequently interdisciplinary, it is even more important to identify scientists and social scientists working and contributing substantially at the cross-field leading edge.

"Is there a formula for managing discovery making? First, and most important, are the people involved."[13]

The late Nobel laureate Ahmed H. Zewail, California Institute of Technology

The 6,389 Highly Cited Researchers of 2020 are unevenly distributed by field, in accordance with the size of each. The table below summarizes the number of researchers in each ESI field and in the cross-field category.

Figure 6: Highly Cited Researchers by ESI field and cross-field category

ESI field	Number of Highly Cited Researchers
Agricultural Sciences	111
Biology and Biochemistry	243
Chemistry	249
Clinical Medicine	482
Computer Science	124
Economics and Business	101
Engineering	173
Environment/Ecology	202
Geosciences	151
Immunology	199
Materials Science	203
Mathematics	70
Microbiology	133
Molecular Biology and Genetics	206
Neuroscience and Behavior	212
Pharmacology/Toxicology	144
Physics	179
Plant and Animal Sciences	220
Psychiatry/Psychology	171
Social Sciences, General	200
Space Science	123
Total	**3896**
Cross-field	**2493**
Grand total	**6389**

[13] Ahmed Zewail, "Curiouser and curiouser: Managing discovery making," *Nature*, 468 (7322): 347, November 18, 2010. DOI: 10.1038/468347a

The following analysis is based on primary researcher affiliations, as specified by the Highly Cited Researchers themselves.

The United States is the institutional home for 2,650 of the Highly Cited Researchers in 2020, which amounts to 41.5% of the group, down from 2,737 or 44.0% in 2019. By contrast, of all papers indexed in Web of Science for 2009 to 2019 the percentage with a U.S. author or co-author was 26.3%. Mainland China is second this year, with 770 Highly Cited Researchers, or 12.1%, up from 636 and 10.2% last year. The United Kingdom, with 514 researchers or 8.0%, is third. Rounding out the top 10, all with 100 or more Highly Cited Researchers, are Germany (345), Australia (305), Canada (195), the Netherlands (181), France (160), Switzerland (154), and Spain (103). These figures do not include the few cases in which a Highly Cited Researcher opted to list a primary affiliation that represented a Research Fellowship rather than a permanent home base.

The Highly Cited Researchers in 2020 work in some 60 countries/regions, but 84.1% are from these 10 and 71.7% from the first five, a remarkable concentration of top talent.

As mentioned, Mainland China has increased its share of Highly Cited Researchers significantly in recent years: from 482 or 7.9% in 2018 (covering the period 2006 to 2016), to 636 or 10.2% in 2019 (2008 to 2018), to 770 or 12.1% this year (2009 to 2019).

Of course, world share is a zero-sum game so as Mainland China increases its stable of Highly Cited Researchers other countries/regions decline. This year we observe a significant 2.5% loss in Highly Cited Researchers for the United States. The United Kingdom and Spain exhibit a decline of .3% since last year. Meanwhile, Australia is powering ahead, moving from a 4.4% share in 2019 to a 4.8% share this year. Other changes were marginal and the ranking of countries/regions in the top 10 remains the same as in 2019.

The headline story then is one of sizeable gains for Mainland China and large losses for the United States, which reflects a transformational rebalancing of scientific and scholarly contributions at the top level through the globalization of the research enterprise.

Figure 7: Highly Cited Researchers by country or region

Rank	Country/region	Number of Highly Cited Researchers	Percent of Highly Cited Researchers
1	United States	2650	41.5
2	China Mainland	770	12.1
3	United Kingdom	514	8.0
4	Germany	345	5.4
5	Australia	305	4.8
6	Canada	195	3.1
7	The Netherlands	181	2.8
8	France	160	2.5
9	Switzerland	154	2.4
10	Spain	103	1.6

The university with the greatest number of Highly Cited Researchers is Harvard, as it has been in past years. Its 188 Highly Cited Researchers for 2020 are nearly twice as many as third ranked Stanford University, with 106.

Figure 8: Highly Cited Researchers by institutions

Institutions	Country/ region	Number of researchers	Institutions	Country/ region	Number of researchers
Harvard University	U.S.	188	University of Melbourne	Australia	36
Chinese Academy of Sciences	China Mainland	124	University of Washington	U.S.	36
Stanford University	U.S.	106	University of Texas MD Anderson Cancer Center	U.S.	35
National Institutes of Health	U.S.	103	Dana-Farber Cancer Institute	U.S.	34
Max Planck Society	Germany	70	Icahn School of Medicine at Mount Sinai	U.S.	34
University of California Berkeley	U.S.	62	Universite Paris Saclay	France	34
Broad Institute	U.S.	61	University of Queensland	Australia	34
University of California San Diego	U.S.	56	Massachusetts General Hospital	U.S.	32
Tsinghua University	China Mainland	55	University of New South Wales Sydney	Australia	32
Washington University of St Louis	U.S.	54	European Molecular Biology Laboratory (EMBL)	Germany	30
Massachusetts Institute of Technology	U.S.	53	University of Minnesota	U.S.	30
University of Oxford	U.K.	52	University of Science & Technology of China	China Mainland	30
Memorial Sloan Kettering Cancer Center	U.S.	51	California Institute of Technology	U.S.	29
Yale University	U.S.	50	University of Chicago	U.S.	29
University of California San Francisco	U.S.	46	King's College London	U.K.	27
University of Cambridge	U.K.	46	National University of Singapore	Singapore	27
University of Pennsylvania	U.S.	46	Princeton University	U.S.	27
Columbia University	U.S.	45	University of British Columbia	Canada	27
Johns Hopkins University	U.S.	42	University of Michigan	U.S.	27
Cornell University	U.S.	41	Utrecht University	Netherlands	27
Swiss Institute of Bioinformatics	Switzerland	41	Imperial College London	U.K.	26
University College London	U.K.	41	University of Toronto	Canada	26
King Abdulaziz University	Saudi Arabia	40	Northwestern University	U.S.	25
University of California Los Angeles	U.S.	40	Wellcome Trust Sanger Institute	U.K.	25
University of North Carolina Chapel Hill	U.S.	40	Ghent University	Belgium	24
Nanyang Technological University	Singapore	39	New York University	U.S.	24
Duke University	U.S.	37	Peking University	China Mainland	24
King Saud University	Saudi Arabia	36	Wageningen University & Research	Netherlands	24
Mayo Clinic	U.S.	36	Zhejiang University	China Mainland	24

In the 2019 ranking of institutions with 24 or more Highly Cited Researchers, 54 organizations – whether universities, government agencies, or other entities – were listed. Using the same threshold, 58 organizations appear in 2020. Notable changes from last year to this year include: the dramatic rise of Tsinghua University by 10 ranks, now placing it in the top 10; an even larger move by Nanyang Technological University of 15 places, taking it to 26th; a leap of 13 ranks for University of Science and Technology of China; and new entrants including Peking University and Zhejiang University. The story of Mainland China's increasing capacity and contribution by the scientific elite shows clearly in these data.

Among governmental and other types of research organizations, the Chinese Academy of Sciences heads the list (124), followed by the U.S. National Institutes of Health (103), the Max Planck Society (70), the Broad Institute (61), Memorial Sloan Kettering Cancer Center (50), and the Swiss Institute of Bioinformatics (41).

Among the 3,896 researchers named as Highly Cited in the 21 ESI fields, 203, or 5.2%, appear in two ESI fields and only 9 (listed below), or .2%, appear in three or more fields. (Cross-field researchers, of which there are 2,493, qualify in only one category, or else they would have been chosen in one or more ESI fields.)

Figure 9: Highly Cited Researchers recognized across three ESI fields

Name	Primary Affiliation	ESI Fields
Jinde Cao	Southeast University, China Mainland	Computer Science, Engineering, Mathematics
Yi Cui	Stanford University, United States	Chemistry, Engineering, Materials Science
Michael Grätzel	Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland	Chemistry, Engineering, Materials Science
Rob Knight	Univ California San Diego, United States	Biology and Biochemistry, Environment/Ecology, Microbiology, Molecular Biology and Genetics
Robert S. Langer	MIT, United States	Biology and Biochemistry, Materials Sciences, Pharmacology/Toxicology
Ju H. Park	Yeungnam University, South Korea	Computer Science, Engineering, Mathematics
Detlef P. van Vuuren	Utrecht University, The Netherlands	Environment/Ecology, Geosciences, Social Sciences
Ramnik Xavier	Broad Institute, United States	Immunology, Microbiology, Molecular Biology and Genetics
Jiaguo Yu	Wuhan University of Technology, China Mainland	Chemistry, Engineering, Materials Science

It is important to understand the difference between selection as a Highly Cited Researcher in the cross-field category and selection in more than one ESI field. Both classes of individuals have demonstrated significant research influence across fields. Cross-field researchers, however, qualify for selection based on the sum of their highly cited papers and citations that meets a normalized threshold equivalent to selection in any one field whereas those named in multiple fields qualify outright in each field.

Finally, and again this year as last year, a filter was applied to remove researchers whose level of self-citation exceeded, by far, the typical patterns of each field.[14] This procedure has and will continue to help maintain the purpose of our selection process and the integrity of our data: to identify researchers with broad community influence and not those whose citation profile is narrow and substantially self-generated.

[14] Jonathan Adams, David Pendlebury, and Martin Szomszor, "How much is too much? The difference between research influence and self-citation excess," *Scientometrics*, 123 (2): 1119–1147, May 2020. DOI: 10.1007/s11192-020-03417-5

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Contact our experts today:

+1 215 386 0100 (U.S.)
+44 (0) 20 7433 4000 (Europe)

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