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Science Revisited: Another Centenary of *Citation Classics*

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Over the years we have produced a number of citation studies. Some have concentrated on individual journals, such as our earlier study of *Science*[1] and our recent analyses of the *Journal of Experimental Medicine* (*JEM*)[2] and the *Journal of Clinical Investigation* (*JCI*).[3]

In addition to these journal studies, we develop annual lists and analyses of the most-cited papers in the life, physical, and chemical sciences. Economic and space considerations dictate that we choose cutoff points, so we usually highlight from 50 to 100 papers. These arbitrary thresholds cause certain problems. Papers below these thresholds may not significantly differ in quality from those above the threshold. Were we to try to select the "best," however, we would need a board of experts. And inevitably there will always be a certain bias due to field size, age, and other factors.

One advantage of these studies is that they provide a way for us to identify candidates for our *Citation Classic*® series. We often select candidates by examining the highly cited papers for particular journals. While our selections may seem to exhibit a bias for high-impact journals, this is not the case. By selecting papers from even the smallest journals we provide a representative list. However, the majority of significant contributions in science are reported in a relatively small number of high-impact journals. One of them, of course, is *Science*.

For this study, we identified the articles that have been cited at least 50 times between 1955 and 1986 in the *Science Citation Index*® (*SCI*®). We found that, out of a total of 50,842 items, *Science* has published about 6,180 articles at this threshold. Figure 1 compares the cumulative citation-frequency distribution for *Science*, *Proceedings of the National Academy of Sciences of the United States of America* (*PNAS*), and *Nature*. Of 28,988 items published between 1955 and 1986, *PNAS* has published about 8,990 that have been cited 50 or more times. *Nature* has about 8,750 articles from a total of 100,388 that have been cited 50 or more times.

These data need to be evaluated carefully. Were we to do an analysis based on articles published only in the last 10 years, we might find different percentages from those shown in Figure 1. In any case it is clear that *Science* has provided us with a very large list of potential candidates for the *Citation Classic* series.

From the list of *Science* papers cited 50 or more times, we chose the 194 papers that have been cited more than 400 times. We then eliminated those papers included in any of our prior citation studies. (If you would like a list of these papers, simply contact me at ISI®.) The resulting list contains another centenary of high-impact papers. They are listed alphabetically by first author in the Bibliography at the end of this essay.

The Goal of *Science*

Our 1981 essay on *Science* provided a detailed discussion of the journal's history, which I won't repeat here.[1] It had a rocky start when the first two editors tried unsuccessfully to publish it, first in 1880 and again in 1883. But in 1895 the third editor, James McKeen Cattell, managed to develop the journal into a successful venture. We have recently discussed the state of science journals published 100 years ago.[4] Upon Cattell's death in 1944, control of the journal passed to the American Association for the Advancement of Science.

In a letter to mineralogist George F. Kunz, partially reprinted in *Science* in 1962, Cattell described his purpose for *Science* as an aid "in the advancement of science in America and at the present time. We have no one centre—such as London and Paris—where men of science are stimulated by personal contact and the interchange of ideas.... It is of especial importance for men of science working in one department to be informed of what is being accomplished in others. In order that science may advance as a whole, specialization by each requires co-operation by all."[5]

Cattell's goal for the journal was upheld by the succeeding editors, including Philip H. Abelson, who assumed editorship of *Science* in 1962. During Abelson's tenure, circulation doubled from 75,000 to 155,000. The "News and Comments" and "Research News" sections expanded from 2 to 14 pages.[6]

In January 1985 Daniel E. Koshland succeeded Abelson as editor. In his first *Science* editorial Koshland affirmed Cattell's goal, which had been established almost 90 years earlier. Koshland wrote that "there is a great need for a journal to serve not only the community within its discipline but also the information flow between disciplines. *Science* has reported on and published scholarly articles in the entire spectrum from mathematics to social science, and this new editor would like to carry on that tradition and possibly improve and enlarge it."[7]

Under Koshland's guidance, the journal now publishes articles covering a wider variety of science fields. We examined issues of *Science* from the first three months of 1984, when the magazine was under Abelson, and the first three months of 1987, when Koshland was editor. We found that Koshland, a biochemist, has published a slightly smaller percentage of articles dealing with the life sciences while providing more articles on astronomy and astrophysics, politics and economics, chemistry, and physics.

The goals envisioned and implemented by Cattell, and more recently by Abelson and Koshland, have served the journal well. According to the 1985 *Journal Citation Reports®*, *Science* articles published in 1983 and 1984 received over 20,000 citations in 1985, ranking it the fourth most-cited journal among the over 4,300 journals indexed. The citations to these two current years of *Science* represent nearly a quarter, or 24 percent, of the citations *Science* received in 1985. This is significantly more than the average of 18 percent for the entire *SCI* file. Similarly, both *Nature* and *PNAS* received about 23 percent.

In terms of immediacy, that is, the percentage of citations to 1985 articles in 1985, the following numbers apply: *Science*, 2.5; *PNAS*, 2.2; and *Nature*, 2.7 percent. The immediacy of *Science* and *Nature* are comparable. Keep in mind that immediacy is slightly affected by the publication of many letters.

Editorial Procedures

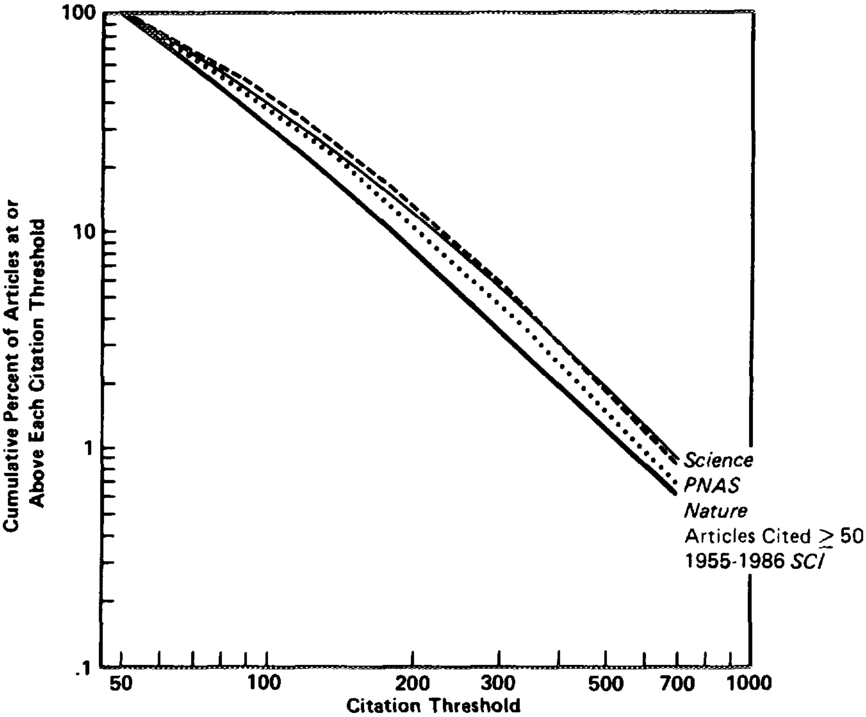
Koshland has instituted some procedural changes intended to speed up the manuscript decision process, although it is not clear yet if these changes have affected immediacy. All manuscripts are given to members of the Board of Reviewing Editors, who appraise a paper in terms of interest, quality, or relevance to major problems. The reviewers rate the paper on a scale from 1 to 10.

Based on these ratings, the editorial staff returns 60 percent of the manuscripts to the authors within 10 days and sends the remaining manuscripts out for further review. This quick turnaround allows authors to submit rejected papers elsewhere since no resubmissions of manuscripts to *Science* are allowed.

Lobbying or phoning review board members to influence their decisions is prohibited. Koshland reasons that the reviewing editors "were chosen for their Solomonic wisdom, their mercurial response times, and their encyclopedic knowledge, qualities achieved by being exceedingly busy scientists."[8]

The high prestige of *Science* helps it to attract important papers on many topics, but it still publishes heavily in the life sciences. Science writers watch for this journal much the way they do for *Nature*, *New England Journal of Medicine* (*NEJM*), *JAMA—Journal of the American Medical Associa-*

Figure 1: Graph of the cumulative citation-frequency distribution, 1955-1986 *SCI®*, for articles with 50 or more citations and for those articles cited 50 or more times from *Nature*, *Proceedings of the National Academy of Sciences of the United States of America* (*PNAS*), and *Science*.



Cumulated Number of Articles for Each Journal with the Cumulated Percent of Total in Parentheses

Citation Threshold	*Nature*		*PNAS*		*Science*		1955-1986 *SCI*	
700	64	(0.7)	68	(0.8)	56	(0.9)	2,411	(0.6)
500	123	(1.4)	161	(1.8)	115	(1.9)	4,874	(1.2)
400	211	(2.4)	264	(2.9)	188	(3.0)	7,738	(1.9)
300	410	(4.7)	500	(5.6)	329	(5.3)	14,183	(3.5)
250	589	(6.7)	748	(8.3)	487	(7.9)	20,680	(5.1)
200	905	(10.3)	1,163	(12.9)	727	(11.8)	32,335	(7.9)
150	1,596	(18.3)	1,954	(21.7)	1,189	(19.2)	57,266	(14.1)
100	3,212	(36.7)	3,864	(43.0)	2,404	(38.9)	124,027	(30.5)
75	4,968	(56.8)	5,785	(64.3)	3,671	(59.4)	208,196	(51.2)
50	8,750	(100.0)	8,990	(100.0)	6,183	(100.0)	406,744	(100.0)

tion, and the *Lancet*, as these publications also have high public visibility. As long as publishing original research remains the main function of this journal, it will continue to thrive in the face of stiff competition from dozens of other primary scientific journals.

Research Fronts

In 1985 we identified 8,500 ISI research fronts. Of these, 2,043 include 1985 articles published in *Science*. Table 1 lists the eight life-sciences fronts in which 19 or more articles were published. These fronts are primarily concerned with nucleotide sequencing, oncology, and immunology. Of the 1,118 papers on the "Effects of leukemia virus on human T-cells in patients with leukemia and acquired immunodeficiency syndrome (AIDS)" (#85-1825), 4 percent were published in *Science*.

Table 2 lists seven 1985 research fronts on the physical and earth sciences. *Science*

Table 1: Classification of 1985 *Science* life-sciences articles using ISI® research fronts ranked by number of *Science* articles the fronts contain. A = number of *Science* articles. B = total number of published (citing) papers. C = number of core documents.

Number	Name	A	B	C
85-1406	Isolation, characterization, expression, and cloning of DNA and RNA nucleotide sequences	113	6,184	26
85-1825	Effects of leukemia virus on human T cells in patients with leukemia and acquired immunodeficiency syndrome (AIDS)	48	1,118	56
85-2912	Isolation, purification, and characterization of proteins and antigens from various species using monoclonal antibodies and other methods	42	7,571	4
85-0208	Expression of c-*myc* gene and other oncogenes causing cancers	42	1,185	51
85-1677	Regulation, characterization, and expression of transcription promoter genes in cells	35	829	32
85-4231	Gene expression in murine cells after transformation by virus DNA	22	429	4
85-2623	Oncogenes and growth-factor receptors and their roles in gene expression and transformation in normal and cancer cells	19	607	7
85-0178	Monoclonal antibody activation of T cells and antigen-receptor-gene expression	19	740	39

Table 2: Classification of 1985 *Science* physical- and earth-sciences articles using ISI® research fronts ranked by number of *Science* articles the fronts contain. A = number of *Science* articles. B = total number of published (citing) papers. C = number of core documents.

Number	Name	A	B	C
85-3757	Atmospheric, climatic, and smoke-transport models showing nuclear winter as an effect of nuclear war	9	130	14
85-2874	Measurement of atmosphere, ocean, and biosphere carbon levels and relationships to land use changes	8	158	21
85-0302	Comets and asteroids, and models of cometary and planetary formation	7	148	29
85-3494	Heat transport, structure, and effect on climate of tropical Atlantic currents	7	61	7
85-4803	Magnetic-field propagation in a stellar convective dynamo	4	114	10
85-0959	El Nino, southern oscillations, and other seasonal anomalies of atmospheric temperature and climate	4	369	43
85-3060	Geology, chemistry, and microbiology of deep-sea hydrothermal vents on the Eastern Pacific Rise and other mid-ocean ridges	4	193	22

published four or more papers on each of these topics that year. The most "popular" area was "Atmospheric, climatic, and smoke-transport models showing nuclear winter as an effect of nuclear war" (#85-3757). This topic was identified by 14 highly cited core papers or books. One hundred thirty papers were published in this subject, of which 7 percent appeared in *Science*. We have discussed research fronts in fuller detail earlier.[9]

Author Information

The bylines of the 100 papers in the Bibliography include 232 authors—4 of them are winners of the Nobel Prize in physiology or medicine. It is significant that none of the authors in this list have received the Nobel in physics or chemistry. As we have often demonstrated, other journals like the *Journal of the American Chemical Society* and *Physical Review* publish the classic work in these fields. While the Nobel lectures in these fields are published in *Science*, these papers may or may not be cited by chemists and physicists as often as the primordial works leading to the awards.

Otto H. Warburg, Kaiser Wilhelm Institute (now the Max Planck Institute), Berlin, Federal Republic of Germany (FRG), received the 1931 prize for his discovery of the mode of action of the respiratory enzyme. Julius Axelrod, National Institutes of Health (NIH), Bethesda, Maryland, shared the 1970 prize for his work on the storage, release, and inactivation of the humoral transmitter. Andrew Schally, Veterans Administration Hospital, New Orleans, Louisiana, shared the 1977 prize with Roger Guillemin and Rosalyn Yalow for their discoveries concerning peptide hormone pro-

Table 3: Article-by-article analysis of *Science* source items, 1978-1981, and their 1978-1983 *SCI®* citations.

	Total Items	Percent Total Items	Number Cited 1978-1983	Percent Cited	1978-1983 Citations	Percent Total Citations	Cited Impact	Total Impact
Articles	3,954	55.4	3,727	94.3	81,829	92.3	22.0	20.7
Editorials	2,066	28.9	775	37.5	2,250	2.5	2.9	1.1
Letters	850	11.9	207	24.4	453	0.5	2.2	0.5
Notes	39	0.5	14	35.9	34	0.0	2.4	0.9
Reviews*	23	0.3	22	95.7	1,289	1.5	58.6	56.0
Proceedings	122	1.7	111	91.0	2,760	3.1	22.6	22.6
All Others	88	1.2	1	1.1	1	0.0	1.0	0.0
Total	**7,142**	**100.0**	**4,857**	**68.0**	**88,616**	**100.0**	**18.2**	****12.4**

*This heading does not include book reviews from *Science*, which we resumed indexing in the 1983 *SCI*.

**Combining four years of source data with only six years of citation data reduces the long-term impact of the items. This occurs because the articles published later, in 1980 and 1981, have had less time for citations to accumulate. In contrast to the total impact of 12.4 given above, the five-year impact for items published in 1980 alone and cited in the 1981-1985 *SCI* is 31.8.

duction in the brain. And neurobiologist David H. Hubel, Harvard Medical School, Boston, was a corecipient with Torsten Nils Wiesel and Roger W. Sperry of the 1981 prize for the analysis of the flow of nerve impulses from the retina of the eye to the sensory and motor centers of the brain.

Twelve articles in this study have been featured in *Citation Classic* commentaries. These commentaries provide personal insights of the authors, demonstrating how human the scientific process actually is. In one commentary, Donald E. Mosier, Research Pathology Section, Fox Chase Cancer Center, Philadelphia, wrote, "I had just finished my first year of medical school and I was overcome with the ennui that only a year of gross anatomy taken among a herd of overachieving med students can produce. I took a leave of absence and sought refuge in the laboratory."[10] During a three-year hiatus from medical school, Mosier established that T and B lymphocytes must interact to induce antibody formation.

The authors identified in the Bibliography are affiliated with 64 institutions in seven countries: Australia, Canada, the FRG, Israel, Sweden, the UK, and the US. Authors from these countries commonly appear in our studies of the most-cited life-sciences articles.[11] The various branches of the NIH lead the institutional list, appearing 13 times, followed closely by the University of California and Harvard University. Without a larger sample, however, one should not generalize about the way *Science* selects papers or the general productivity of the institutions involved.

Article-by-Article Data

Science editors publish lead editorials that often find resonance in the scientific world. How often do these pieces get cited explicitly? To find out we used our article-by-article analysis audit program. Table 3 shows 1978 to 1983 citations to the various types of *Science* source items from 1978 to 1981. Citation totals from 1978 to 1983 are provided. By combining four years of source data with only six years of citation data, the articles published between 1979 and 1981 have had less time to be cited. Therefore, the long-term impact of such items is reduced. However, in our study of the *JCI*,[3] we provided a table comparing the six-year impact factors for five medical journals: *British Medical Journal*, *JAMA*, the *Lancet*, *NEJM*, and *JCI*. The impact factors for these five journals fell between 2.7 and 39.4. In this study, Table 3 shows *Science* has a five-year impact factor of 31.8, which compares favorably with these five medical journals.

For coding purposes in the *SCI*, we distinguish 11 categories to describe cited items. For instance, we code articles and surveys of previously published literature as "review" items. Most papers with more than 100 references are coded as review items. While certain items may logically be assigned to more than one category, we choose only one category per item. The

Table 4: Frequency distribution of publication dates for the 100 articles in the Bibliography.

Publication Date	Number of Articles
1950-1954	5
1955-1959	5
1960-1964	11
1965-1969	26
1970-1974	33
1975-1979	17
1980-1985	3

Nobel lectures, which are published each year in *Science*, are coded as research articles but could just as easily be considered "reviews," since they generally discuss the laureates' work leading to the Nobel Prize.

If you think that the number of "editorials" in Table 3 seems rather high, you are correct. We code all types of nonresearch items as editorial source items in the *SCI*. We include not only the typical one-page editorials by Koshland or associate editors but also the short comments by staff writers.

We analyzed each issue of *Science* published between 1978 and 1981 to find how often the "true" editorial columns were explicitly cited. Two hundred four of the 2,066 listed in Table 3 were the lead, one-page editorials. Nearly 50 percent of these lead editorials received a total of 200 citations between 1978 and 1983. Of the remaining items coded as editorials, 37 percent were cited. The most-cited editorial published between 1978 and 1981 is a 1979 piece about informed consent for participants in experimental studies.[12] Written by Elizabeth F. Loftus, then at the Center for Advanced Study in the Behavioral Sciences, Stanford, California, and James F. Fries, professor of medicine, Stanford University, this editorial has been explicitly cited 15 times since it was published. It is difficult to evaluate the influence of these editorials from citation data. Undoubtedly, many of the citing items were letters, but any writer of editorials is pleased to learn that his or her informed opinions are quoted at all. And who knows how often they were quoted in the lay press!

Noteworthy Articles

About 70 percent of the research articles in the Bibliography were published between 1960 and 1974, as shown in the frequency distribution of publication dates (Table 4). This 15-year period dominates due to the increase in the size of the scientific literature. Our earlier studies of the *JEM*[2] and the *JCI*[3] show a similar distribution, with over 60 percent of the articles we studied published during this period. The publication-year data provided here for *Science* are not directly comparable, however, in that the list does not include any papers published earlier than the 1950s. In another recent study of *JAMA*, we analyzed the publication-date distribution of items cited in the *SCI* between 1955 and 1984. We found that the number of items cited prior to 1950 represents 11.8 percent of all items cited, while those items from 1950 to 1959 are 13.6 percent of all items cited.[13]

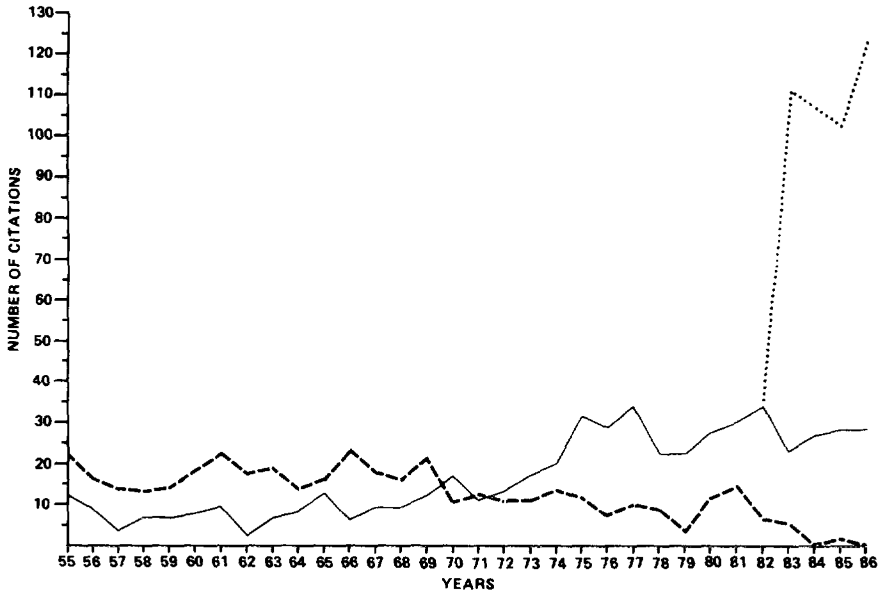
Two articles published in 1952 are the oldest in this study. Russell J. Barrnett, Departments of Anatomy and Surgery, Harvard Medical School, and Arnold M. Seligman, Yasmins Laboratory for Surgical Research, Beth Israel Hospital, Boston, developed a new reagent to detect sulfhydryl groups in tissue sections. Sulfhydryl groups are involved in the contractile activity of muscle, coagulation of blood, and in hormone synthesis and activity. The paper describing this reagent has been cited over 400 times, but year-by-year citation data plotted in Figure 2 show that citations have fallen off in recent years.

The other 1952 article in the Bibliography was written by the late B.H.J. Hofstee, then with the Palo Alto Medical Research Foundation, California. Cited over 500 times, this article elaborated on the Michaelis-Menten theory of enzyme action by studying the constants of an enzyme system. Figure 2 shows that the number of citations to this article has increased over the years, but it is not a case of delayed recognition.

The most recent paper was published in 1981 by Ronald B. Herberman and John R. Ortaldo, National Cancer Institute (NCI), Bethesda. This paper summarizes the characteristics of natural killer cells and discusses their potential role in mediating natural resistance against tumors. Figure 2 shows how this paper has become highly cited in a very brief time.

About 20 percent of the articles in the Bibliography deal with immunology. In the ear-

Figure 2: A year-by-year comparison of citations received by the two oldest and by the most recent *Science* articles in the study. **Solid line**=Hofstee B H J (116:329-31, 1952). **Broken line**=Barrnett R J (116:323-7, 1952). **Dotted line**=Herberman R B (214:24-30, 1981).



ly 1960s Theodore L. Goodfriend, Lawrence Levine, and Gerald D. Fasman, Graduate Department of Biochemistry, Brandeis University, Waltham, Massachusetts, developed a method to enhance the normally weak antibody production against substances of low molecular weight. These antibodies are provoked by injecting compounds containing a small molecule that has been conjugated, or united, with proteins via organic synthesis. Goodfriend and colleagues used carbodiimides as conjugating agents to join proteins and small polypeptides. The authors suggest that this method may be used to immunize against toxic compounds of low molecular weight. This paper received 28 cites in 1986 and 6 cites as of March 1987, demonstrating its continued popularity.

A few plant-sciences papers appear in the Bibliography. One paper by P.F. Scholander, director, Physiological Research Laboratory, Scripps Institution of Oceanography, University of California, San Diego, and colleagues describes a method to measure the negative sap pressure in the xylem, a tubular tissue that conducts fluids in vascular plants. This measurement method supported the cohesion theory that explains how sap defies gravity and travels from the roots to the tops of trees. In the near future we will publish an analysis of the most-cited plant-sciences articles. This and other fields covered in *Science* will of necessity be less than adequately represented for a variety of reasons outlined before. By comparison, ecology fared quite well in relation to the size of its literature—at least four of the papers in the Bibliography concern this field.

The most-cited paper from the Bibliography is a 1979 paper by Patrick C. Kung and Gideon Goldstein, Ortho Pharmaceutical Corporation, Raritan, New Jersey, and Ellis L. Reinherz and Stuart F. Schlossman, Division of Tumor Immunology, Sidney Farber Cancer Institute, Harvard Medical School. The authors used the hybridoma technique developed by Nobel laureates César Milstein and Georges J.F. Köhler, whose work we discussed previously.[14] Briefly, this technique involves developing antibody-producing cells that are hardy enough to grow in culture. Kung and coworkers used this technique to study the human T cell, a lymphocyte that differentiates into a variety of cells with different functions that play major roles in the body's immune response. The authors developed hybridomas that secrete monoclonal antibodies that recognize the distinct subclasses of the human T cell. These antibodies are invaluable for learning more about the different functions of the T cell, which may lead to diagnostic and therapeutic applications in clinical medicine.

Conclusion

Within the last five years, *Science* has published many research articles concerning AIDS and the identification of the AIDS virus. In our study of the most-cited 1984 life-sciences articles, 23 out of the 102 papers studied dealt with AIDS. Ten of these were published in *Science*. These 10 documents were core to two of the five AIDS-related research fronts included in that study.[11] Of the 56 core papers for #85-1825, mentioned earlier, 23 were from *Science*.

Were we to include an analysis of hot research fronts in which the core (cited) papers were emphasized rather than the number of papers currently published (citing), then journals like *Science* might feature even more prominently. In fast-moving fields such as AIDS, current papers dominate the core. Papers by the Montagnier group at the Pasteur Institute, Paris,[15,16] and the Gallo group at NCI[17] achieved *Citation Classic* status within one year.

In its 107-year history, *Science* has played a major role in the progress of scientific research. Hundreds of *Citation Classics* have been published in this journal over the decades. The 100 papers included in this study are just a fraction of the *Science* articles that have had high impact in the research world. In more recent years, *Science* has also become a major voice in the growing field of science journalism.

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My thanks to Lisa Holland and Pat Taylor for their help in the preparation of this essay.

REFERENCES

1. **Garfield E.** *Science*: 101 years of publication of high impact science journalism. *Essays of an information scientist.* Philadelphia: ISI Press, 1983. Vol. 5. p. 253-60. (Reprinted from: *Current Contents* (39):5-12, 28 September 1981.)
2. --------------. Ninety-one *Citation Classics* from the *Journal of Experimental Medicine*. *Current Contents* (28):3-13, 13 July 1987.
3. --------------. Fifty classics from the *Journal of Clinical Investigation*: over 60 years of Nobel-class research. *Current Contents* (8):3-11, 23 February 1987.
4. --------------. The 170 surviving journals that *CC* would have covered 100 years ago. *Current Contents* (26):3-12, 29 June 1987.
5. **Wolfle D.** 1895. *Science* 137:643, 1962.
6. **Koshland D E.** Philip Hauge Abelson. *Science* 227:13, 1985.
7. --------------. An editor's quest (I). *Science* 227:123, 1985.
8. --------------. An editor's quest (II). *Science* 227:249, 1985.
9. **Garfield E.** Towards scientography. *Current Contents* (43):3-14, 27 October 1986.
10. **Mosier D E.** Citation Classic. Commentary on *Science* 158:1573-5, 1967. (Barrett J T, ed.) *Contemporary classics in the life sciences. Vol. 1: cell biology.* Philadelphia: ISI Press, 1986. p. 69.
11. **Garfield E.** The most-cited 1984 life-sciences articles highlight AIDS research. *Current Contents* (49):3-17, 8 December 1986.
12. **Loftus E F & Fries J F.** Informed consent may be hazardous to health. *Science* 204:11, 1979.
13. **Garfield E.** *Citation Classics* from *JAMA*: how to choose landmark papers when your memory needs jogging. *Current Contents* (31):3-15, 3 August 1987.
14. --------------. The 1984 Nobel Prize in medicine is awarded to Niels K. Jerne, César Milstein, and Georges J.F. Köhler for their contributions to immunology. *Essays of an information scientist: ghostwriting and other essays.* Philadelphia: ISI Press, 1986. Vol. 8. p. 416-31.
15. **Barré-Sinoussi F, Chermann J C, Rey F, Nugeyre M T, Chamaret S, Gruest J, Dauguet C, Axler-Blin C, Vézinet-Brun F, Rouzioux C, Rozenbaum W & Montagnier L.** Isolation of a T-lymphotropic retrovirus from a patient at risk for acquired immune deficiency syndrome (AIDS). *Science* 220:868-71, 1983.
16. **Barré-Sinoussi F, Chermann J-C & Montagnier L.** Citation Classic. Commentary on *Science* 220:868-71, 1983. *Current Contents/Life Sciences* 30(8):18, 23 February 1987.
17. **Gallo R C, Sarin P S, Gelmann E P, Robert-Guroff M, Richardson E, Kalyanaraman V S, Mann D, Sidhu G D, Stahl R E, Zolla-Pazner S, Leibowitch J & Popovic M.** Isolation of human T-cell leukemia virus in acquired immune deficiency syndrome (AIDS). *Science* 220:865-7, 1983.

Bibliography: The 100 highly cited articles from *Science* from the 1955-1986 *SCI*®. These are among the most-cited articles and have appeared in no other *Current Contents*® (*CC*®) study. Articles are listed in alphabetic order by first author. Asterisks (*) indicate articles with *Citation Classic*® commentaries. The issue number, year, and edition of *CC* in which these commentaries appeared are in parentheses.

Number of 1955-1986 *SCI* Citations	Bibliographic Data
467	**Arimura A, Sato H, Dupont A, Nishi N & Schally A V.** Somatostatin: abundance of immunoreactive hormone in rat stomach and pancreas. *Science* 189:1007-9, 1975.
405	**Aserinsky E & Kleitman N.** Regularly occurring periods of eye motility, and concomitant phenomena, during sleep. *Science* 118:273-4, 1953.
458	**Bach F & Hirschhorn K.** Lymphocyte interaction: a potential histocompatibility test in vitro. *Science* 143:813-4, 1964.
403	**Barrnett R J & Seligman A M.** Histochemical demonstration of protein-bound sulfhydryl groups. *Science* 116:323-7, 1952.
592	**Benda P, Lightbody J, Sato G, Levine L & Sweet W.** Differentiated rat glial cell strain in tissue culture. *Science* 161:370-1, 1968.
716	**Blattner F R, Williams B G, Blechl A E, Denniston-Thompson K, Faber H E, Furlong L-A, Grunwald D J, Kiefer D O, Moore D D, Schumm J W, Sheldon E L & Smithies O.** Charon phages: safer derivatives of bacteriophage lambda for DNA cloning. *Science* 196:161-9, 1977.
458	***Bonner J, Dahmus M E, Fambrough D, Huang R C, Marushige K & Tuan D Y H.** The biology of isolated chromatin. *Science* 159:47-56, 1968. (4/84/LS)
639	**Bretscher M S.** Membrane structure: some general principles. *Science* 181:622-9, 1973.
550	**Brooks J L & Dodson S I.** Predation, body size, and composition of plankton. *Science* 150:28-35, 1965.
612	***Brown D D & Dawid I B.** Specific gene amplification in oocytes. *Science* 160:272-80, 1968. (31/83/LS)
540	**Cameron J R & Sorenson J.** Measurement of bone mineral in vivo: an improved method. *Science* 142:230-2, 1963.
495	**Carson P E, Flanagan C L, Ickes C E & Alving A S.** Enzymatic deficiency in primaquine-sensitive erythrocytes. *Science* 124:484-5, 1956.
540	**Catt K & Tregear G W.** Solid-phase radioimmunoassay in antibody-coated tubes. *Science* 158:1570-2, 1967.
401	**Chervenick P A & LoBuglio A F.** Human blood monocytes: stimulators of granulocyte and mononuclear colony formation in vitro. *Science* 178:164-6, 1972.
494	**Chung E & Miller E J.** Collagen polymorphism: characterization of molecules with the chain compositon $[\alpha 1(\mathrm{III})]_3$ in human tissues. *Science* 183:1200-1, 1974.
430	**Connell J H.** Diversity in tropical rain forests and coral reefs. *Science* 199:1302-10, 1978.
396	**Cooper D Y, Levin S, Narasimhulu S, Rosenthal O & Estabrook R W.** Photochemical action spectrum of the terminal oxidase of mixed function oxidase systems. *Science* 147:400-2, 1965.
496	**Damadian R.** Tumor detection by nuclear magnetic resonance. *Science* 171:1151-3, 1971.
526	**Darnell J E, Philipson L, Wall R & Adesnik M.** Polyadenylic acid sequences: role in conversion of nuclear RNA into messenger RNA. *Science* 174:507-10, 1971.
423	**Darnell J E, Jelinek W R & Molloy G R.** Biogenesis of mRNA: genetic regulation in mammalian cells. *Science* 181:1215-21, 1973.
464	**Dawson D M, Goodfriend T L & Kaplan N O.** Lactic dehydrogenases: functions of the two types. *Science* 143:929-33, 1964.
630	***Deutsch H F & Morton J I.** Dissociation of human serum macroglobulins. *Science* 125:600-1, 1957. (22/79/LS)
490	**Emlen S T & Oring L W.** Ecology, sexual selection, and evolution of mating systems. *Science* 197:215-23, 1977.
446	**Feinstone S M, Kapikian A Z & Purcell R H.** Hepatitis A: detection by immune electron microscopy of a viruslike antigen associated with acute illness. *Science* 182:1026-8, 1973.
479	**Fernstrom J D & Wurtman R J.** Brain serotonin content: physiological dependence on plasma tryptophan levels. *Science* 173:149-52, 1971.
484	**Fernstrom J D & Wurtman R J.** Brain serotonin content: physiological regulation by plasma neutral amino acids. *Science* 178:414-6, 1972.
474	**Fishman P H & Brady R O.** Biosynthesis and function of gangliosides. *Science* 194:906-15, 1976.
576	**Fitch W M & Margoliash E.** Construction of phylogenetic trees. *Science* 155:279-84, 1967.
661	**Fridovich I.** The biology of oxygen radicals. *Science* 201:875-80, 1978.
737	**Goodfriend T L, Levine L & Fasman G D.** Antibodies to bradykinin and angiotensin: a use of carbodiimides in immunology. *Science* 144:1344-6, 1964.

Number of 1955-1986 *SCI* Citations	Bibliographic Data
406	**Habermann E.** Bee and wasp venoms. *Science* 177:314-22, 1972.
675	**Hamburger A W & Salmon S E.** Primary bioassay of human tumor stem cells. *Science* 197:461-3, 1977.
408	**Hays J D, Imbrie J & Shackleton N J.** Variations in the earth's orbit: pacemaker of the ice ages. *Science* 194:1121-32, 1976.
549	**Henle W, Henle G, Zajac B A, Pearson G, Waubke R & Scriba M.** Differential reactivity of human serums with early antigens induced by Epstein-Barr virus. *Science* 169:188-90, 1970.
484	**Herberman R B & Ortaldo J R.** Natural killer cells: their role in defenses against disease. *Science* 214:24-30, 1981.
646	**Hirata F & Axelrod J.** Phospholipid methylation and biological signal transmission. *Science* 209:1082-90, 1980.
541	**Hofstee B H J.** On the evaluation of the constants V_m and K_M in enzyme reactions. *Science* 116:329-31, 1952.
483	**Hokfelt T, Kellerth J O, Nilsson G & Pernow B.** Substance P: localization in central nervous system and in some primary sensory neurons. *Science* 190:889-90, 1975.
476	**Hubel D H.** Tungsten microelectrode for recording from single units. *Science* 125:549-50, 1957.
516	**Huber H, Polley M J, Linscott W D, Fudenberg H H & Muller-Eberhard H J.** Human monocytes: distinct receptor sites for the third component of complement and for immunoglobulin G. *Science* 162:1281-3, 1968.
664	**Huxley H E.** The mechanism of muscular contraction. *Science* 164:1356-66, 1969.
542	***Iversen L L.** Dopamine receptors in the brain. *Science* 188:1084-9, 1975. (28/84/LS)
553	**Jensen E V & DeSombre E R.** Estrogen-receptor interaction. *Science* 182:126-34, 1973.
570	***King J L & Jukes T H.** Non-Darwinian evolution. *Science* 164:788-98, 1969. (34/83/LS)
396	**King M C & Wilson A C.** Evolution at two levels in humans and chimpanzees. *Science* 188:107-16, 1975.
436	**Klein D C & Weller J L.** Indole metabolism in pineal gland: a circadian rhythm in *N*-acetyltransferase. *Science* 169:1093-5, 1970.
402	**Klein J.** Major histocompatibility complex of the mouse. *Science* 203:516-21, 1979.
528	**Kornberg R D & Thomas J O.** Chromatin structure: oligomers of the histones. *Science* 184:865-8, 1974.
1,034	**Kung P C, Goldstein G, Reinherz E L & Schlossman S F.** Monoclonal antibodies defining distinctive human T cell surface antigens. *Science* 206:347-9, 1979.
461	**LaDue J S, Wroblewski F & Karmen A.** Serum glutamic oxaloacetic transaminase activity in human acute transmural myocardial infarction. *Science* 120:497-9, 1954.
408	**Langan T A.** Histone phosphorylation: stimulation by adenosine 3',5'-monophosphate. *Science* 162:579-80, 1968.
589	**LaVail J H & LaVail M M.** Retrograde axonal transport in the central nervous system. *Science* 176:1416-7, 1972.
459	**Lichtenstein L M & Margolis S.** Histamine release in vitro: inhibition by catecholamines and methylxanthines. *Science* 161:902-3, 1968.
448	**Lieberman M & Kaplan H S.** Leukemogenic activity of filtrates from radiation-induced lymphoid tumors of mice. *Science* 130:387-8, 1959.
518	***Lindell T J, Weinberg F, Morris P W, Roeder R G & Rutter W J.** Specific inhibition of nuclear RNA polymerase II by α-amanitin. *Science* 170:447-9, 1970. (29/84/LS)
482	**LoBuglio A F, Cotran R S & Jandl J H.** Red cells coated with immunoglobulin G: binding and sphering by mononuclear cells in man. *Science* 158:1582-5, 1967.
583	**Lowy D R, Rowe W P, Teich N & Hartley J W.** Murine leukemia virus: high-frequency activation in vitro by 5-iododeoxyuridine and 5-bromodeoxyuridine. *Science* 174:155-6, 1971.
589	**Maizel J V.** Acrylamide-gel electrophorograms by mechanical fractionation: radioactive adenovirus proteins. *Science* 151:988-90, 1966.
512	**Marchesi V T & Andrews E P.** Glycoproteins: isolation from cell membranes with lithium diiodosalicylate. *Science* 174:1247-8, 1971.
625	**Markert C L.** Lactate dehydrogenase isozymes: dissociation and recombination of subunits. *Science* 140:1329-30, 1963.
398	**Mayer D J, Wolfle T L, Akil H, Carder B & Liebeskind J C.** Analgesia from electrical stimulation in the brainstem of the rat. *Science* 174:1351-4,1971.
441	**Mazur P.** Cryobiology: the freezing of biological systems. *Science* 168:939-49, 1970.
441	**McCord J M.** Free radicals and inflammation: protection of synovial fluid by superoxide dismutase. *Science* 185:529-31, 1974.
492	***McGaugh J L.** Time-dependent processes in memory storage. *Science* 153:1351-8, 1966. (33/84/LS)

Number of 1955-1986 *SCI* Citations	Bibliographic Data
464	**Meister A.** On the enzymology of amino acid transport. *Science* 180:33-9, 1973.
461	**Mertz E T, Bates L S & Nelson O E.** Mutant gene that changes protein composition and increases lysine content of maize endosperm. *Science* 145:279-80, 1964.
522	**Miller O L & Beatty B R.** Visualization of nucleolar genes. *Science* 164:955-7, 1969.
634	***Mosier D E.** A requirement for two cell types for antibody formation in vitro. *Science* 158:1573-5, 1967. (25/83/LS)
427	**Myers C E, McGuire W P, Liss R H, Ifrim I, Grotzinger K & Young R C.** Adriamycin: role of lipid peroxidation in cardiac toxicity and tumor response. *Science* 197:165-7, 1977.
587	***Nowell P C & Hungerford D A.** A minute chromosome in human chronic granulocytic leukemia. *Science* 132:1497, 1960. (8/85/LS)
618	**Nowell P C.** The clonal evolution of tumor cell populations. *Science* 194:23-8, 1976.
533	**Odum E P.** The strategy of ecosystem development. *Science* 164:262-70, 1969.
443	***Pastan I & Perlman R.** Cyclic adenosine monophosphate in bacteria. *Science* 169:339-44, 1970. (47/84/LS)
486	**Patrick J & Lindstrom J.** Autoimmune response to acetylcholine receptor. *Science* 180:871-2, 1973.
666	**Razin A & Riggs A D.** DNA methylation and gene function. *Science* 210:604-10, 1980.
417	**Reisfeld R A & Small P A.** Electrophoretic heterogeneity of polypeptide chains of specific antibodies. *Science* 152:1253-5, 1966.
660	**Ross R & Glomset J A.** Atherosclerosis and the arterial smooth muscle cell. *Science* 180:1332-9, 1973.
402	**Ross R & Harker L.** Hyperlipidemia and atherosclerosis. *Science* 193:1094-100, 1976.
628	**Rotruck J T, Pope A L, Ganther H E, Swanson A B, Hafeman D G & Hoekstra W G.** Selenium: biochemical role as a component of glutathione peroxidase. *Science* 179:588-90, 1973.
624	**Said S I & Mutt V.** Polypeptide with broad biological activity: isolation from small intestine. *Science* 169:1217-8, 1970.
633	**Schildkraut J J & Kety S S.** Biogenic amines and emotion. *Science* 156:21-30, 1967.
428	**Schneider G E.** Two visual systems. *Science* 163:895-902, 1969.
611	**Schoener T W.** Resource partitioning in ecological communities. *Science* 185:27-39, 1974.
987	**Scholander P F, Hammel H T, Bradstreet E D & Hemmingsen E A.** Sap pressure in vascular plants. *Science* 148:339-46, 1965.
417	**Shiu R P C, Kelly P A & Friesen H G.** Radioreceptor assay for prolactin and other lactogenic hormones. *Science* 180:968-71, 1973.
421	**Sidman M.** Avoidance conditioning with brief shock and no exteroceptive warning signal. *Science* 118:157-8, 1953.
504	***Stein G S, Spelsberg T C & Kleinsmith L J.** Nonhistone chromosomal proteins and gene regulation. *Science* 183:817-24, 1974. (50/84/LS)
436	**Stent G S.** The operon: on its third anniversary. *Science* 144:816-20, 1964.
399	**Stryer L.** Fluorescence spectroscopy of proteins. *Science* 162:526-33, 1968.
704	**Trager W & Jensen J B.** Human malaria parasites in continuous culture. *Science* 193:673-5, 1976.
401	**Trentin J J, Yabe Y & Taylor G.** The quest for human cancer viruses. *Science* 137:835-41, 1962.
578	***Vyas G N & Shulman N R.** Hemagglutination assay for antigen and antibody associated with viral hepatitis. *Science* 170:332-3, 1970. (6/84/CP)
628	**Warburg O.** On the origin of cancer cells. *Science* 123:309-14, 1956.
438	**Wasserman R H & Taylor A N.** Vitamin D_3-induced calcium-binding protein in chick intestinal mucosa. *Science* 152:791-3, 1966.
436	**Watkins W M.** Blood-group substances. *Science* 152:172-81, 1966.
411	**Wheelock E F.** Interferon-like virus-inhibitor induced in human leukocytes by phytohemagglutinin. *Science* 149:310-1, 1965.
437	**Whittaker R H & Feeny P P.** Allelochemics: chemical interactions between species. *Science* 171:757-70, 1971.
402	**Williams R C & Gibbons R J.** Inhibition of bacterial adherence by secretory immunoglobulin A: a mechanism of antigen disposal. *Science* 177:697-9, 1972.
432	**Wolfe D E, Potter L T, Richardson K C & Axelrod J.** Localizing tritiated norepinephrine in sympathetic axons by electron microscopic autoradiography. *Science* 138:440-2, 1962.
495	**Young C W & Hodas S.** Hydroxyurea: inhibitory effect on DNA metabolism. *Science* 146:1172-4, 1964.