The Overproduction of Truth

Passion, competition and integrity in modern science

Gianfranco Pacchioni

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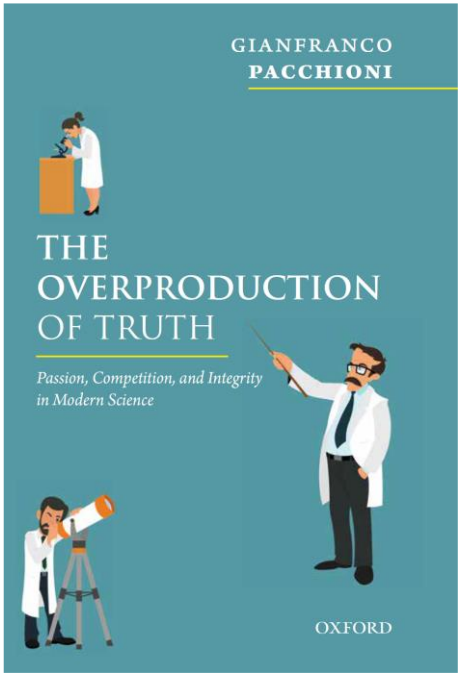
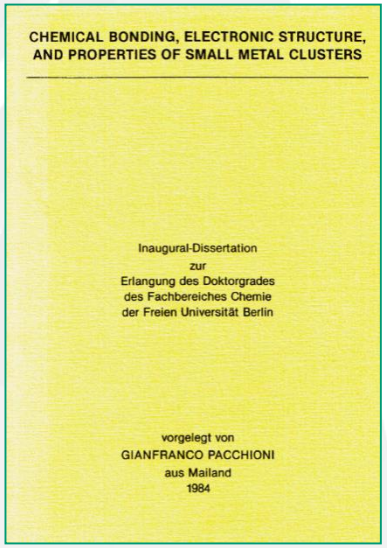


PERSONAL PERSPECTIVE…


CHEMICAL BONDING, ELECTRONIC STRUCTURE, AND PROPERTIES OF SMALL METAL CLUSTERS

Inaugural-Dissertation
zur
Erlangung des Doktorgrades
des Fachbereiches Chemie
der Freien Universität Berlin

vorgelegt von
GIANFRANCO PACCHIONI
aus Mailand
1984

1981-1984: my working instruments

PERSONAL PERSPECTIVE…

1980, one issue of J. Phys. Chem. contained about 30 papers; in that year there were 26 issues for a total of 800 papers and 3660 pages.

1960, 12 issues (one every month), about 20 papers per issue, a bit more than 200 papers and less than 2000 pages overall.

Today (2019) the journal has been divided into four parts, A, B, C e Letters; each part publishes an issue every week, for a total of 177 issues, >6000 papers, 62.0000 pages/year.

SCIENTIFIC CONGRESSES: FROM 1927….

Group photo at the fifth edition of the Solvay conference on Electrons and photons, held in 1927 in Brussels at the Institut International de Physique Solvay. 29 participants, 17 Nobel prizes

A. Piccard, E. Henriot, P. Ehrenfest, E. Herzen, Th. de Donder, E. Schrödinger, J.E. Verschaffelt, W. Pauli, W. Heisenberg, R.H. Fowler, L. Brillouin; P. Debye, M. Knudsen, W.L. Bragg, H.A. Kramers, P.A.M. Dirac, A.H. Compton, L. de Broglie, M. Born, N. Bohr; I. Langmuir, M. Planck, M. Skłodowska-Curie, H.A. Lorentz, A. Einstein, P. Langevin, Ch.-E. Guye, C.T.R. Wilson, O.W. Richardson.

SCIENTIFIC CONGRESSES: … TODAY

American Physical Society: 4 congresses/year 10.000 participants
American Chemical Society: 2 congresses/year 13-18.000 participants
Society for Neurosciences: 30.000 participants
Radiological Society of North America: 52.000 participants (2016)

HOW MUCH DO WE PUBLISH?

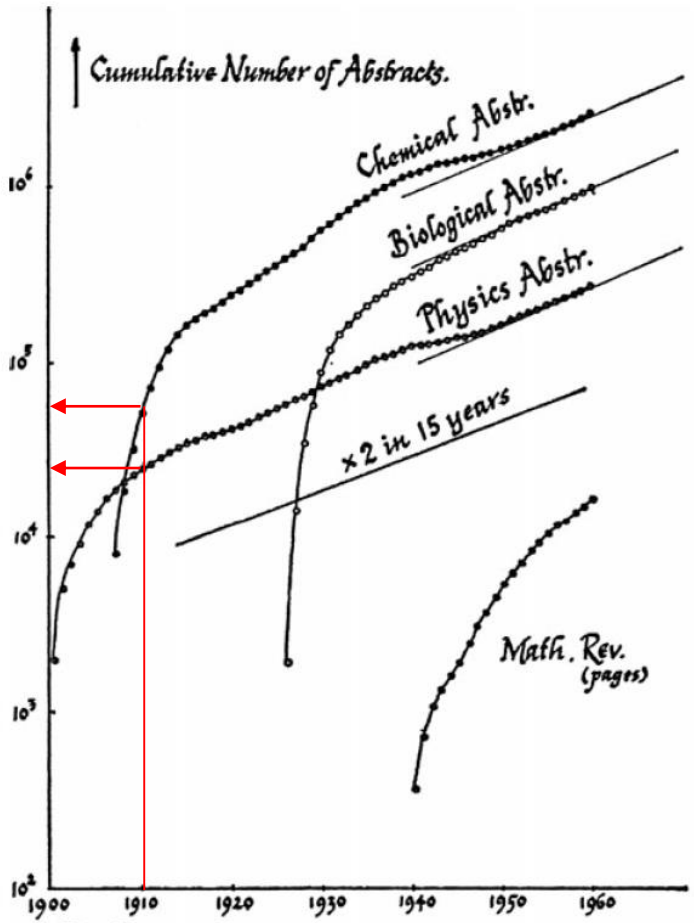


Fig. 2. CUMULATIVE NUMBER OF ABSTRACTS IN VARIOUS SCIENTIFIC FIELDS, FROM THE BEGINNING OF THE ABSTRACT SERVICE TO GIVEN DATE

1963: Derek J. de Solla Price publishes the first quantitative analysis on how scientific knowledge has evolved from 1650 until 1960

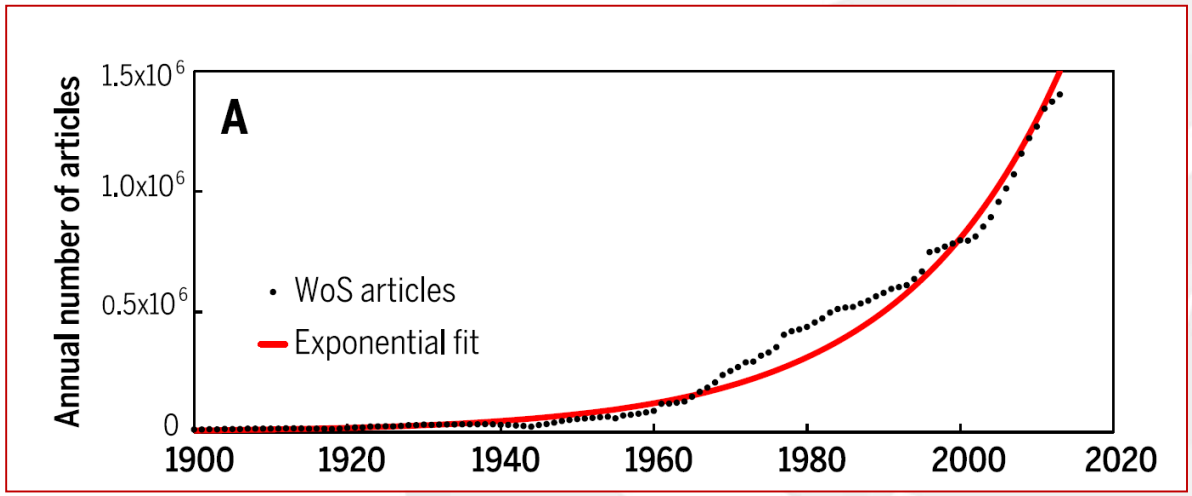
In 1960 there were about two million scientific studies; most of them were produced in the period between 1910 and 1960

The works produced in the two and a half centuries prior to 1910 are of the order of tens of thousands

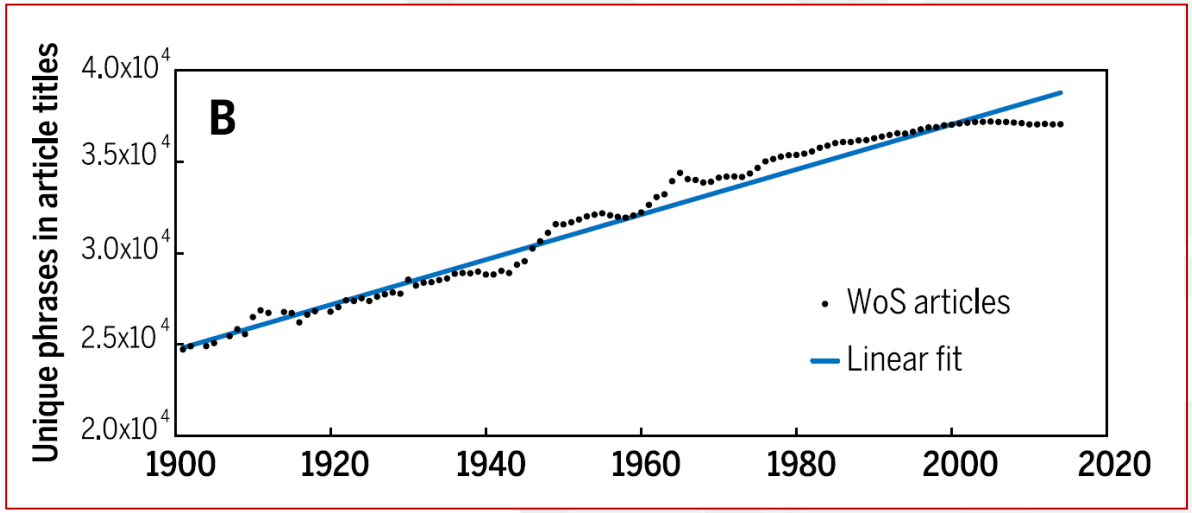
SCIENTIFIC REVOLUTIONS IN XIX CENTURY

1805 - Dalton: atomic theory
1820 - Oersted: relationship between electricity and magnetism
1824 - Carnot: steam machine theory
1827 - Ohm: law on electricity
1827 - Avdogadro: gas laws
1831 - Faraday: electrochemistry
1833 - Payen: isolated the first enzyme
1838 - Bessel: measure of the stellar parallax
1842 - Doppler: Doppler effect
1843 - Joule: law of conservation of energy
1848 - Lord Kelivn: absolute zero
1859 - Darwin: theory of evolution
1861 - Pasteur: the bacteria
1864 - Maxwell: theory of electromagnetism
1865 - Mendel: inheritance, the basics of genetics
1865 - Clausius: definition of entropy
1869 - Mendeleev: periodic table
1871 - Rayleigh: diffraction phenomena
1873 - van der Waals: intermolecular forces
1875 - Crookes: cathode rays
1876 - Gibbs: the chemical thermodynamics
1877 - Boltzmann: statistical thermodynamics
1884 - van't Hoff: osmotic pressure
1887 - Michelson and Morley: demolished the ether theory
1895 - Rongten: X-rays
1897 - Thomson: discovery of the electron
1898 - Marie Curie: radioactivity
1900 - Planck: quantum theory

HOW MUCH DO WE PUBLISH?



Exponential growth of papers



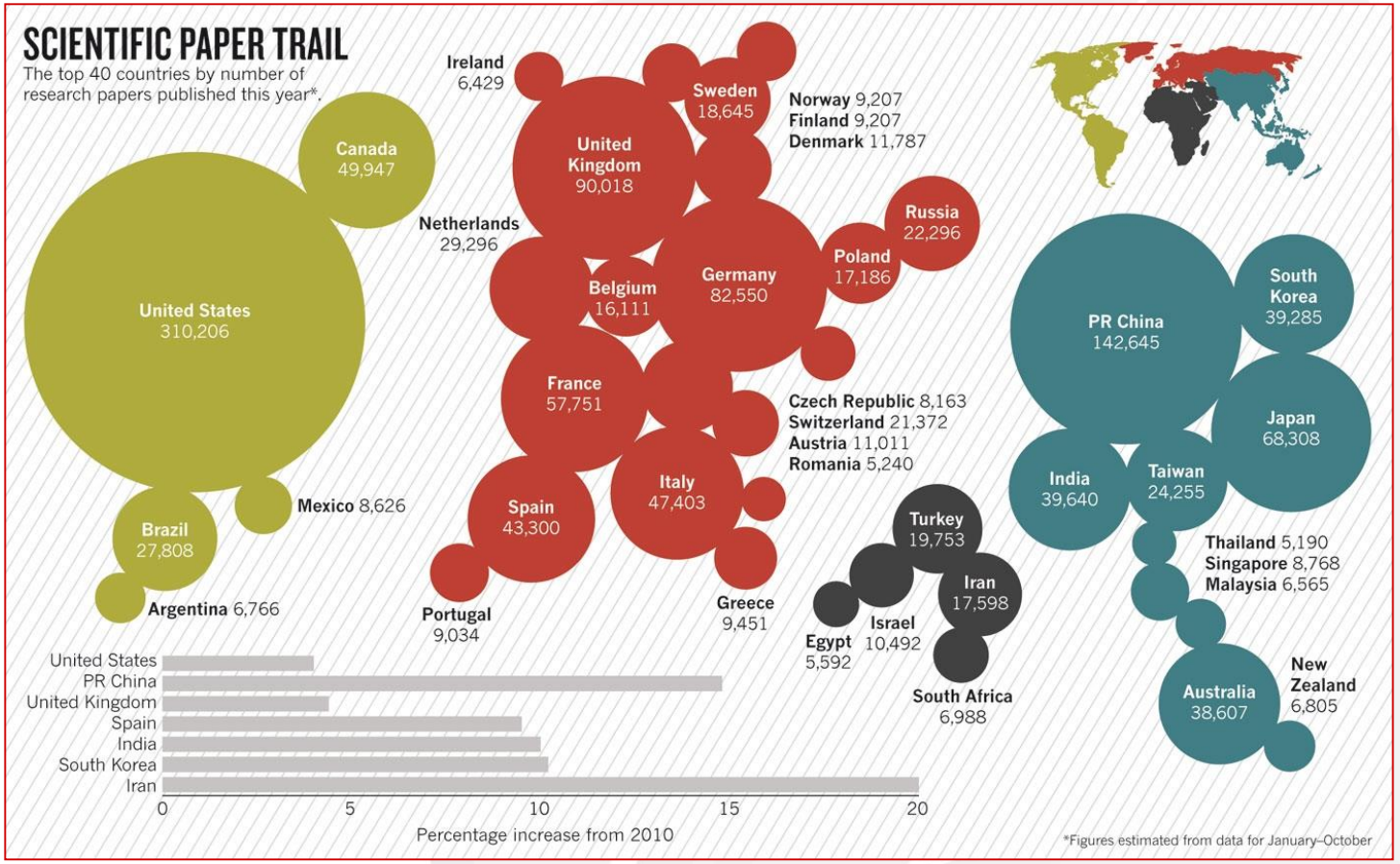
Linear growth of ideas (topics in titles)

Fortunato *et al.*, *Science* **359**, eaao0185 (2018) 2 March 2018

Science AAAS

HOW MUCH DO WE PUBLISH?

Geographic distribution of scientific production in 2011

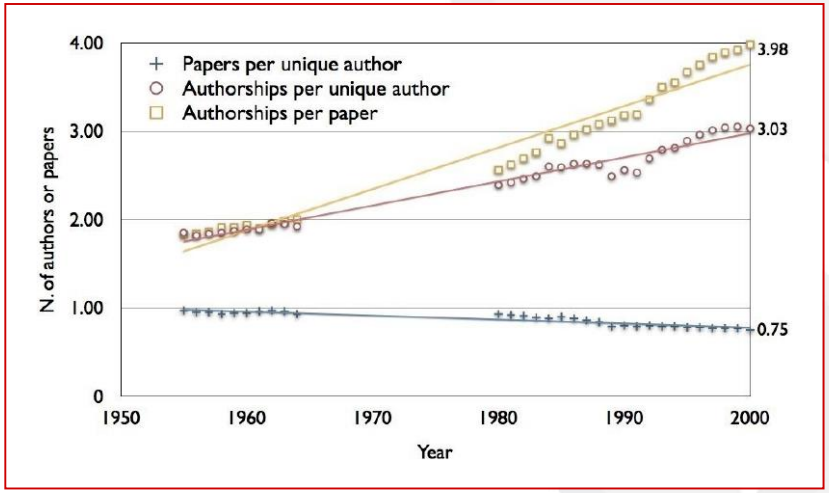


Today, between 2 and 2.4 million scientific articles are published in journals with referee every year, 6600 per day, 5 per minute.

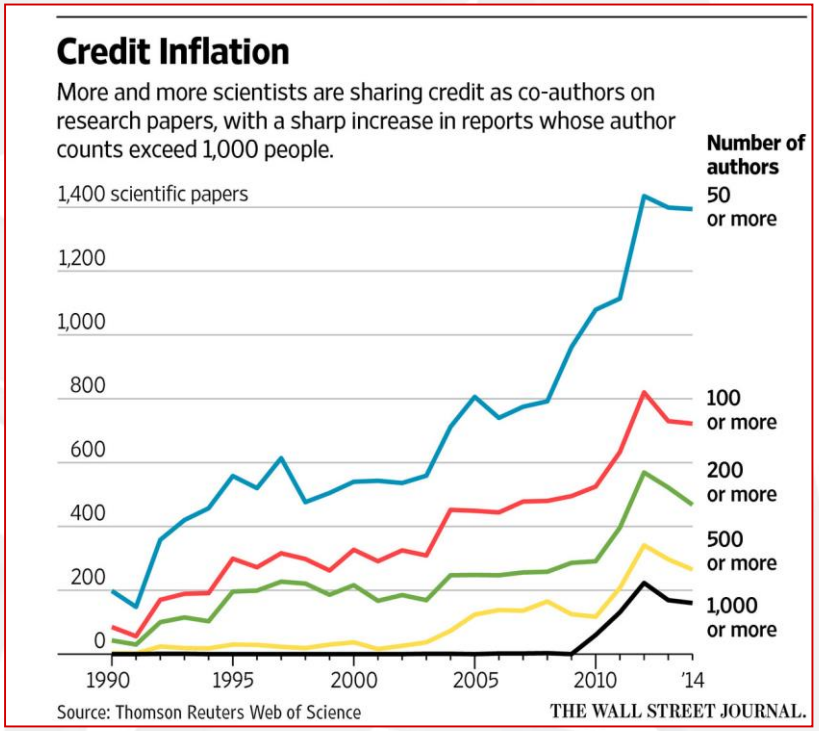
COLLABORATIONS AND MEGA-COLLABORATIONS

Why do we publish more?

Larger number of authors and collaborations



Average number of co-authors per paper 1954-2000



Number of papers from 1998 to 2014 with more than 50, 100, 200, 500, 1000 authors

NUMBER OF AUTHORS ON THE SAME PAPER

Selected for a Viewpoint in *Physics*
PRL **114,** 191803 (2015) PHYSICAL REVIEW LETTERS week ending 15 MAY 2015

Combined Measurement of the Higgs Boson Mass in *pp* Collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS Experiments

G. Aad *et al.*[*]

(ATLAS Collaboration)[†]
(CMS Collaboration)[‡]

(Received 25 March 2015; published 14 May 2015)

A measurement of the Higgs boson mass is presented based on the combined data samples of the ATLAS and CMS experiments at the CERN LHC in the $H \to \gamma\gamma$ and $H \to ZZ \to 4\ell$ decay channels. The results are obtained from a simultaneous fit to the reconstructed invariant mass peaks in the two channels and for the two experiments. The measured masses from the individual channels and the two experiments are found to be consistent among themselves. The combined measured mass of the Higgs boson is $m_H = 125.09 \pm 0.21\,(\text{stat}) \pm 0.11\,(\text{syst})$ GeV.

24 pages of authors (alphabetic order) for a total of 5154 researchers coming from 344 institutions

P. Bartos,[144a,†] A. Bassalat,[117,†] A. Basye,[165,†] R. L. Bates,[53,†] S. J. Batista,[158,†] J. R. Batley,[28,†] M. Battaglia,[137,†] M. Bauce,[132a,132b,†] F. Bauer,[136,†] H. S. Bawa,[143,f,†] J. B. Beacham,[111,†] M. D. Beattie,[72,†] T. Beau,[80,†] P. H. Beauchemin,[161,†] R. Beccherle,[124a,124b,†] P. Bechtle,[21,†] H. P. Beck,[17,g,†] K. Becker,[120,†] M. Becker,[83,†] S. Becker,[100,†] M. Beckingham,[170,†] C. Becot,[117,†] A. J. Beddall,[19c,†] A. Beddall,[19c,†] V. A. Bednyakov,[65,†] C. P. Bee,[148,†] L. J. Beemster,[107,†] T. A. Beermann,[175,†] M. Begel,[25,†] J. K. Behr,[120,†] C. Belanger-Champagne,[87,†] W. H. Bell,[49,†] G. Bella,[153,†] L. Bellagamba,[20a,†] A. Bellerive,[29,†] M. Bellomo,[86,†] K. Belotskiy,[98,†] O. Beltramello,[30,†] O. Benary,[153,†] D. Benchekroun,[135a,†] M. Bender,[100,†] K. Bendtz,[146a,146b,†] N. Benekos,[10,†] Y. Benhammou,[153,†] E. Benhar Noccioli,[49,†] J. A. Benitez Garcia,[159b,†] D. P. Benjamin,[45,†] J. R. Bensinger,[23,†] S. Bentvelsen,[107,†] L. Beresford,[120,†] M. Beretta,[47,†] D. Berge,[107,†] E. Bergeaas Kuutmann,[166,†] N. Berger,[5,†] F. Berghaus,[169,†] J. Beringer,[15,†] C. Bernard,[22,†] N. R. Bernard,[86,†] C. Bernius,[110,†] F. U. Bernlochner,[21,†] T. Berry,[77,†] P. Berta,[129,†] C. Bertella,[83,†] G. Bertoli,[146a,146b,†] F. Bertolucci,[124a,124b,†] C. Bertsche,[113,†] D. Bertsche,[113,†] M. I. Besana,[91a,†] G. J. Besjes,[106,†] O. Bessidskaia Bylund,[146a,146b,†] M. Bessner,[42,†] N. Besson,[136,†] C. Betancourt,[48,†] S. Bethke,[101,†] A. J. Bevan,[76,†] W. Bhimji,[46,†] R. M. Bianchi,[125,†] L. Bianchini,[23,†] M. Bianco,[30,†] O. Biebel,[100,†] S. P. Bieniek,[78,†] M. Biglietti,[134a,†] J. Bilbao De Mendizabal,[49,†] H. Bilokon,[47,†] M. Bindi,[54,†] S. Binet,[117,†] A. Bingul,[19c,†] C. Bini,[132a,132b,†] C. W. Black,[150,†] J. E. Black,[143,†] K. M. Black,[22,†] D. Blackburn,[138,†] R. E. Blair,[6,†] J.-B. Blanchard,[136,†] J. E. Blanco,[77,†] T. Blazek,[144a,†] I. Bloch,[42,†] C. Blocker,[23,†] W. Blum,[83,a,†] U. Blumenschein,[54,†] G. J. Bobbink,[107,†] V. S. Bobrovnikov,[109,d,†] S. S. Bocchetta,[81,†] A. Bocci,[45,†] C. Bock,[100,†] M. Boehler,[48,†] J. A. Bogaerts,[30,†] A. G. Bogdanchikov,[109,†] C. Bohm,[146a,†] V. Boisvert,[77,†] T. Bold,[38a,†] V. Boldea,[26a,†] A. S. Boldyrev,[99,†] M. Bomben,[80,†] M. Bona,[76,†] M. Boonekamp,[136,†] A. Borisov,[130,†] G. Borissov,[72,†] S. Borroni,[42,†] J. Bortfeldt,[100,†] V. Bortolotto,[60a–60c,†] K. Bos,[107,†] D. Boscherini,[20a,†] M. Bosman,[12,†] J. Boudreau,[125,†] J. Bouffard,[2,†] E. V. Bouhova-Thacker,[72,†] D. Boumediene,[34,†] C. Bourdarios,[117,†] N. Bousson,[114,†] A. Boveia,[30,†] J. Boyd,[30,†] I. R. Boyko,[65,†] I. Bozic,[13,†] J. Bracinik,[18,†] A. Brandt,[8,†] G. Brandt,[54,†] O. Brandt,[58a,†] U. Bratzler,[156,†] B. Brau,[86,†] J. E. Brau,[116,†] H. M. Braun,[175,a,†] S. F. Brazzale,[164a,164c,†] K. Brendlinger,[122,†] A. J. Brennan,[88,†] L. Brenner,[107,†] R. Brenner,[166,†] S. 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WEISZ PARADOX (1968)

Flux of scientific papers **N** in time **t**:

$$dN/dt = n \bullet v \bullet p$$

n = number of researchers, v = production speed of an information bit per researcher, p = number of jobs published per information bit

This leads to exponential growth:

$$dN/dt = \exp(k)t$$

where k is a constant to be determined

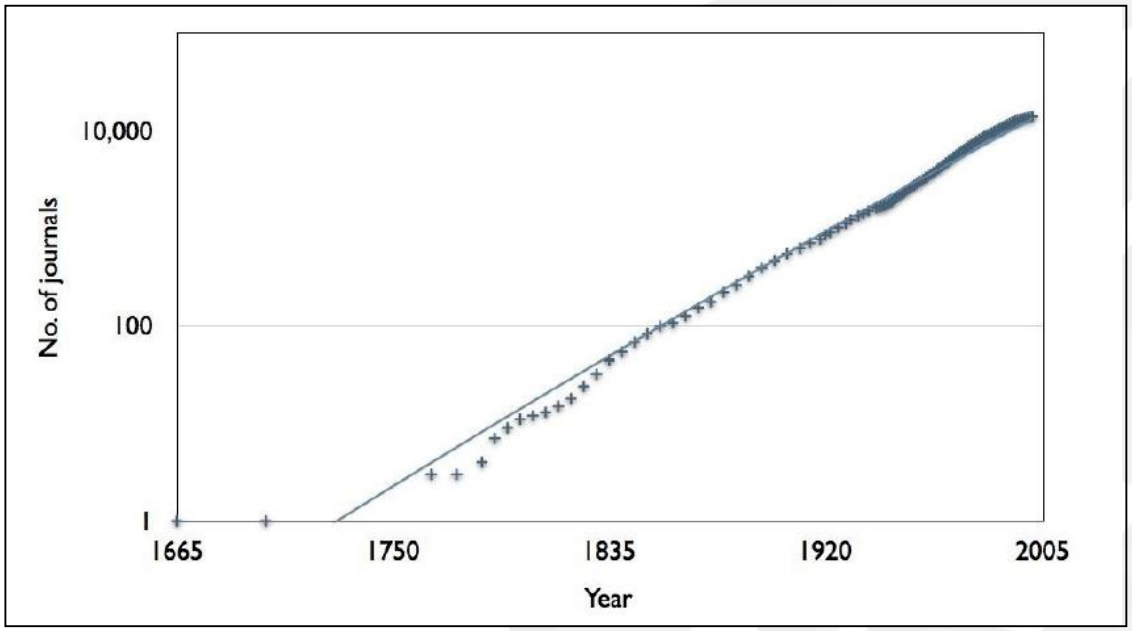
The time to read, understand and digest a scientific article has remained more or less the same and can be approximated to a constant, $(dN/dt)_0$

Conclusion: the fraction *f* of the scientific information that we can assimilate, digest, and process, decreases exponentially with time:

$$f = (dN/dt)_0/(dN/dt) \div 1/\exp(k)t \rightarrow 0$$

Paul B. Weisz, Exponentials, *Advances in Catalysis* 18, vii-ix (1968)

HOW MANY SCIENTIFIC JOURNALS?



The number of scientific journals with reviewers has grown steadily with a rate of about 3.5% per year in the last century

Mabe, The growth and number of journals. *Serials*, 16, 191 (2003)

In 2012 there were 28,000 scientific journals with peer review

This data does not include open archives, conference proceedings and other modern means of communicating results

ARE SCIENTIFIC JOURNALS ALL THE SAME?

1 euro

386 euro

Quality costs….

ARE SCIENTIFIC JOURNALS ALL THE SAME?

High reputation journal

- 10000 manuscripts received every year
- 50 manuscripts per day
- 5 papers/day = 10 editors
- 80% rejection rate = 2000 manuscripts published
- For each published paper, editors have to deal with 5 manuscripts

High selection, high quality, high cost

Low reputation journal

- 400 manuscripts received every year
- 2 manuscripts per day
- 2 papers/day = 1 editor
- 25% rejection rate = 300 manuscripts published
- Very cost effective

Low selection, low quality, low cost

OPEN ACCESS

open access: recent phenomenon (2000) entirely linked to the dematerialization of communication

Publishing costs (text revision, peer review management, website maintenance, etc.) paid directly by the author; there is no copyright, the study can be immediately made public and available to everyone

September 2012:	8115 Open Access journals
April 2018:	11240 Open Access journals
January 2020:	14234 Open Access journals

DOAJ DIRECTORY OF OPEN ACCESS JOURNALS

OPEN ACCESS … GUARANTEED

DOAJ DIRECTORY OF OPEN ACCESS JOURNALS

https://doaj.org/

14.234 Journals
131 Countries
4.597.925 Articles
(2020)

AAAS ADVANCING SCIENCE, SERVING SOCIETY
APS physics
BRILL
co-action PUBLISHING
cogent oa
Copernicus Publications The Innovative Open Access Publisher
DE GRUYTER OPEN
Dovepress
EBSCO
edp sciences
eLIFE
ELSEVIER
ExLibris The bridge to knowledge
frontiers
Hindawi
IOP Publishing
ISSN INTERNATIONAL STANDARD SERIAL NUMBER
JMIR Publications The Leading eHealth Publisher
Karger Open access
LUND UNIVERSITY
MDPI
OpenEdition
palgrave macmillan
PLOS
ProQuest
SAGE
SciELO
SPRINGER NATURE
Taylor & Francis Group an informa business
Thieme
WILEY

OPEN ACCESS … PREDATORY (predatory journals)

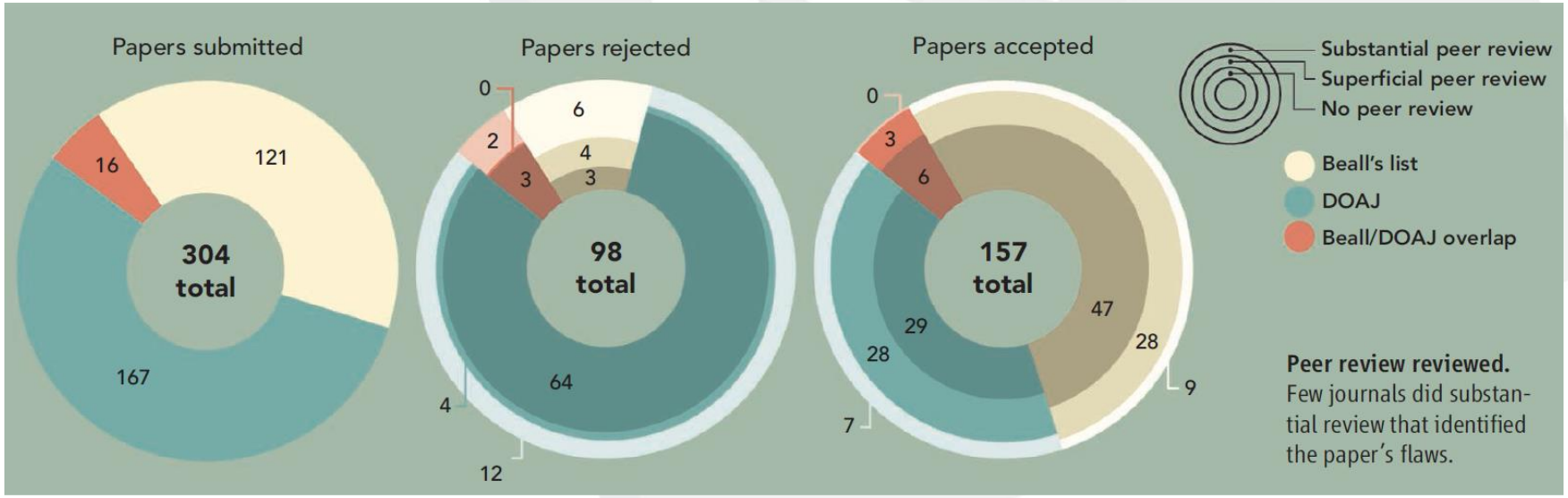
Who's Afraid of Peer Review?

A spoof paper concocted by *Science* reveals little or no scrutiny at many open-access journals

SCIENCE VOL 342 4 OCTOBER 2013

JOHN BOHANNON

Generate 304 copies of a counterfeit work in which it was reported the discovery of a miracle drug, extracted from a lichen, capable of fighting certain types of cancer and sent to OA journals; African author and institution non-existent; paper full of fundamental errors. Result: accepted by about 160 magazines!



OPEN ACCESS … PREDATORY (predatory journals)

Geographical distribution of OA journals (publisher, director, bank account)

Black list Open Access:

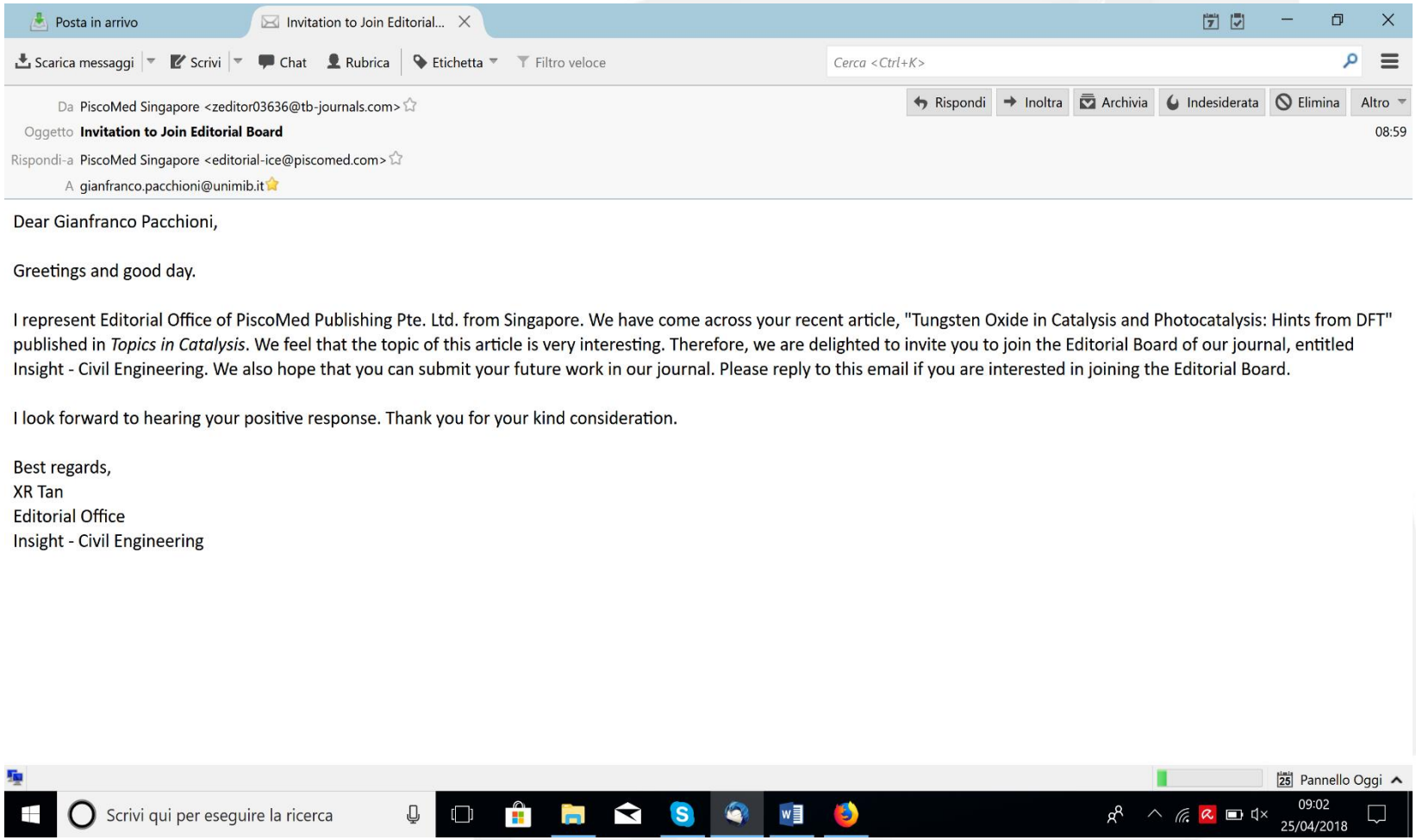
https://scholarlyoa.com/individual-journals/

Predatory publishers are corrupting open access

Journals that exploit the author-pays model damage scholarly publishing and promote unethical behaviour by scientists, argues **Jeffrey Beall**.

13 SEPTEMBER 2012 | VOL 489 | NATURE | 179

OPEN ACCESS ... PREDATORY (predatory journals)



OPEN ACCESS: ADVANTAGES AND DISADVANTAGES

ADVANTAGES

- Free and open access to all literature
- Limiting factor. Since authors have to pay to publish a paper, this could have the beneficial effect to reduce the total number of papers published

DISADVANTAGES

- Free to read, not free to publish (discrimination towards less well funded groups)
- Introduces a monetary transaction between author and publisher (dangerous)
- Phenomenon of predatory journals

PREDATORY CONFERENCES

Invitations received in 24 hours, from 7:00 25.2.1019 till 7.00 26.2.1019

1. SCON 2nd International Conference on Nanotechnology
2. World Congress on Functional Materials and Nanotechnology
3. Global Conference on Neuroscience and Neurology
4. 8th Int. Conference on Advanced Materials and Engineering Materials
5. 10th World Congress of Chemistry & Biology
6. 2th Asian Federation for Medicinal Chemistry Int. Medicinal Chemistry Symposium
7. 5th International Conference on Materials Science & Technology
8. 2nd World Congress on and Biopolymers Bioplasctics
9. Europolymer Conference EUPOC2019
10. The 9th World Congress on Chemistry
11. ICCST-14 International Conference on the Chemistry of Se and Te
12. Global Summit on Materials Research & Nanotechnology
13. International Conference on Catalysis, Advanced Chemical Engineering and Technology
14. Brightlands Rolduc Polymer Conference
15. Applied Science & Innovative Engineering 2019
16. First Global Transitions Conference

SCIENTISTS IN THE PAST AND IN THE FUTURE

1930: 200,000 scientists, 2 billion people, a researcher for every 10,000 inhabitants

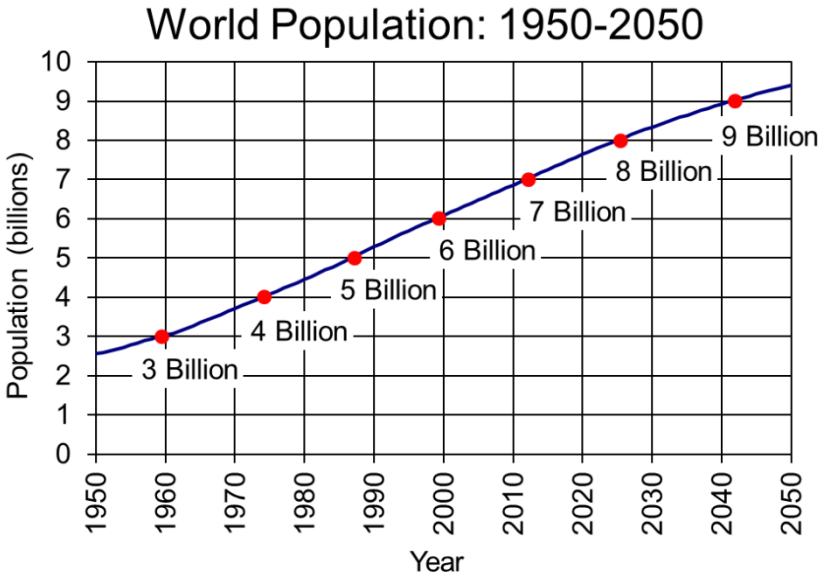
1960: 1,000,000 scientists, 3 billion people, a researcher for every 3,000 inhabitants

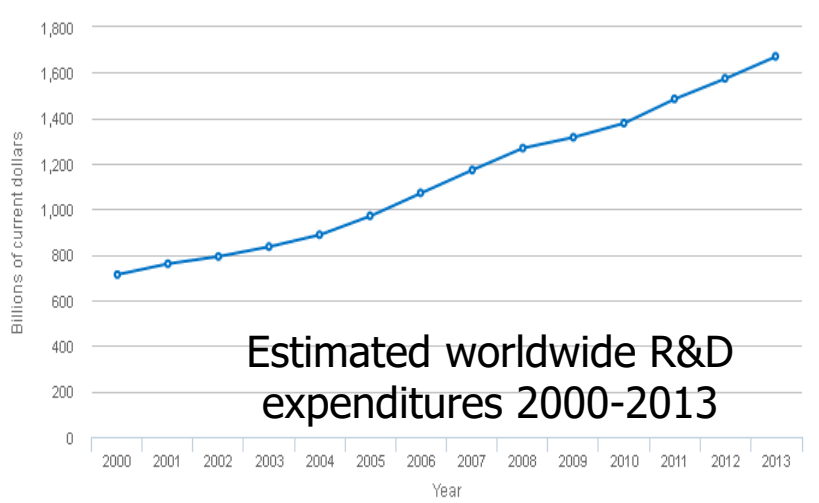
2000: 5,000,000 scientists, 6 billion people, a researcher for every 1,200 inhabitants

2013: 10,000,000 scientists, 7 billion people, a researcher every 700 inhabitants

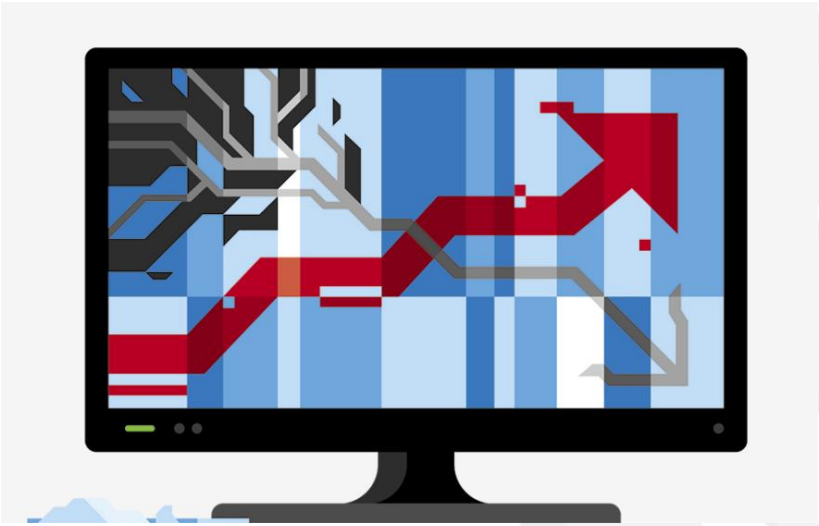
2048: 35,000,000 scientists, 9 billion people, one researcher per 250 inhabitants

One day there will only be scientists in the world





MEASURE OF PERFORMANCES



How to evaluate the success of a TV program in a market driven environment?

Measure audience and share

High audience and share, succesfull program (market driven)

How to evaluate the success of a scientist in a market driven environment?

Measure papers and citations

Many papers and citations, succesfull scientist (market driven)

MODERN SCIENCE: FROM PASSION TO MARKET