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Scientometric Portrait of P.M. Bhargava

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The research publications of P.M. Bhargava, the modern biologist were quantitatively analysed on the basis of year, domain, collaboration pattern, channels of communication, number of pages, number of words and keywords in the titles. His first paper was published in 1947 when he was only 19. His 128 research papers covered in the study were (a) organic chemistry and insecticides (15); (b) liver cell suspensions and uptake of nucleic acids (31); (c) cell division, malignant transformation, regulation of growth, concentration effect, cell cycle and transport (18); (d) reproductive biochemistry (40); (e) mould metabolism (1); (f) tRNA and rRNA (3); (g) protein denaturation (4); (h) pyrimidine metabolism (1); (i) evolution (7); (j) Antarctica microbiology (5); and (k) general perspectives (3) only.

His Publication Productivity Coefficient was 0.58; Publication Density was 1.94; Publication Concentration was 19.70; and Average Bradford Multiplier was 2.31.

He had collaborated with 76 scientists during 1947-94. His eleven papers each were published with A.B. Sen (1947-50); N. Shyamala Rao (1954-92); and S. Shivaji (1984-92).

His research productivity and quality is of an order that can inspire younger researchers and he can be considered as a 'role model scientist' for emulating.

INTRODUCTION

Most scientific and technological activities in India are funded, directly or indirectly, by public money and virtually all scientists and technologists today are salaried people. This leads to the requirement of a continuous assessment of performance, both of the individual scientist or technologist and of the institution or organisation, thus ensuring that neither the scientist, the technologist nor the administrative structure gets stratified and, therefore, fossilised [1].

The report of the Comptroller and Auditor General showed that it was inefficient use of funds and not lack of resources, that was responsible for the failure of scientific departments to meet their targets. Various scientists responded to this statement. M.G.K. Menon insisted that "auditors do not always have a clear understanding of scientific research". Yash Pal emphasised that the accountant's norms "cannot be the same for assessing productivity or efficiency" in scientific research [2].

Scientists have been worried about the fact that India's investment of 1.1 percent of the Gross National Product (GNP) in research and development (R&D) was reduced in 1991 to less than 0.9 percent [3,4]. According to data published by the Department of Science and Technology (DST), Government of India, this expenditure continued to fall during 1992-93.

The country's total expenditure on R&D was US $ 1,754 million in 1992-93. Although this expenditure, in absolute terms, represented an increase over the previous year, as a fraction of GNP, the total budget has been declining steadily since 1988-89, when it peaked at 0.96 percent of GNP.

In 1991-92, this fell to 0.84 percent of GNP, and it dropped still further to 0.83 percent during 1992-93. This is far below the target of two percent commitment in the new science and technology policy.

According to the DST report, most of this money still comes from central and state governments. The private sector share of national R&D expenditure was only 15 percent of the total, and industry spent only 0.57 percent of its sales turnover on R&D [5].

It was observed that scientists in the developing countries produce an estimated five percent of the world's scientific literature. Although this represents a small portion of the whole, it is remarkable taking into consideration the, social, economic and sometime political conditions [6].

Venkataraman said, "It was ironical that India, even though richer in a number of resources has not progressed enough while Japan, a country without any mineral resources has become a world leader" [7].

Despite its late start China has published many more collaborative papers than India has with most Asian countries and the advanced countries of the West, except the UK, confirming the effectiveness of the open door policy of post-Mao China [8].

S.N. Bose, while delivering the K.S. Krishnan Memorial Lecture, remarked, "It is a perpetual challenge to the Indian genius as to how, even though the country is endowed with such natural resources, even though the country has had such a brilliant history, it continues to be third rate".

C.V. Raman had said: "What we lack is perhaps courage, What we lack is perhaps a driving force which takes one anywhere. We have, I think, developed an inferiority complex. I think what is needed in India today is a destruction of that defeatist spirit".

While writing a book review, Krishna commented that "most of the developing countries lack local 'role models' to motivate other scientists" [9]. But Kalyane [10] has suggested to focus research on scientists who have been doing good work in spite of several impediments.

There is no doubt that India has made some important and high quality contributions in selected areas of science. But the total scientific scenario in the country is not altogether encouraging. There are very few men and institutions of excellence. The morals and performance of the average working scientist is not very high [11]. Concerns have been expressed over the slow pace of research and the overall poor quality of science in India [12].

Thus several aspects of the national R&D activities have come up for debate of late. Let us take a positive approach and try to bring out our strengths by following the works of those scientists who have succeeded in doing excellent work in spite of impediments. Reiteration of examples of such scientists will go a long way in not only restoring the confidence of other young scientists but also inspiring the uninitiated ones. An in depth analysis of success stories would no doubt encourage younger scientists to continue in this honourable profession with vigour and determination, overcome hurdles and contribute to raising the status of Indian science and technology.

It is said that we are fast moving from an age of things to an age of thoughts, and an age of mind over matter. In this new age our most precious resource is the mind of man that is free to invent, free to experiment and free to dream. The value of the silicon chip does not lie in the sand from which it comes, but in the microscopic architectures engraved upon it by the ingenious human mind.

The most promising superconductors are made from ceramics - their value does not come from their material, but from the brilliant inspiration of a few scientists. It is human imagination that is going to build the 21st century out of sand and clay [13].

The existing biographies of scientists are descriptive in nature. There are only a few attempts made recently to highlight scientists who could be considered role models, using quantitative methods of analysis, such as bibliometrics, informetrics and scientometrics [14-42].

Scientometrics provides an understanding of the structure of the scientific activity, the disciplines being researched, the organisations involved, the strengths and deficiencies in the scientific groups and their communication channels. Research productivity of a scientist is determined primarily by the ability to (i) recognise a good research problem, (ii) obtain the resources needed to work on this problem, (iii) plan and execute the research project, (iv) write the results and (v) get the results published through perseverance.

P.M. BHARGAVA - MODERN BIOLOGIST

Pushpa Mittra Bhargava was born at Ajmer (Rajasthan) on 22nd February, 1928. He had studied at Theosophical College, Lucknow, and at Queens College, Varanasi, Uttar Pradesh. He passed B.Sc. with Physics, Chemistry and Mathematics (1944). He obtained his M.Sc. in Organic Chemistry (1946) and Ph.D. in Synthetic Organic Chemistry from Lucknow University at the age of 21. He taught Chemistry at Lucknow University for several months, then moved to the Osmania University, Hyderabad, as a lecturer in the Department of Chemistry. Several months later he joined as Research Fellow (First of the Laboratory and then of the National Institute for Science of India), the Central Laboratories for Scientific and Industrial Research. In 1953, he went to the US on a post-doctoral fellowship as Project Associate at the McArdle Memorial Laboratory for Cancer Research, University of Wisconsin, Madison, USA. While there, he decided to pursue a career in the field of biology in the laboratory of Charles Heidelberger and played an active part in the discovery of 5-fluorouracil, the well-known anti-cancer drug. After three years he joined the National Institute for Medical Research in the UK as a special Wellcome Research Fellow for one year, and returned to Hyderabad in 1958 where he joined as Scientist B at the then Regional Research Laboratory (now known as the Indian Institute of Chemical Technology). He worked in various capacities in IICT. He worked for 15 months in 1971-72 at the Institute du Radium, Orasay, Paris, France as an Eleanor Roosevelt International Cancer Research Fellow.

His independent research career has been mostly at Hyderabad where he founded the Centre for Cellular and Molecular Biology (CCMB) having state-of-the-art facilities, comparable internationally. CCMB is widely recognised as one of the finest institutions in the world doing research in frontier areas of modern biology. It is known not only for the quality of its scientific work but also for its innovative and efficient management and for its value system. It was among the first institutions to be elected to UNESCO's prestigious network of institutes of the highest levels of excellence in cellular and molecular biology in the world.

He conceived the idea of establishment of the CSIR Centre for Biochemicals in New Delhi. He was one of the earliest users and supporters of the radioisotopes programme of the Bhabha Atomic Research Centre, which is now known as Board of Radiation and Isotope Technology (BRIT). He was responsible for conceiving the idea of and the setting up of Jonaki, a Department of Atomic Energy Laboratory for preparation of p.32 - labelled nucleotide molecules, at Hyderabad. This laboratory makes radioactive chemicals needed for genetic engineering and other areas of molecular biology and has provided India self-sufficiency in this regard.

He founded the prestigious Guha Research Conference, an Indian professional society. He also played a major role in the setting up of the Department of Biotechnology (Government of India) and initiated major programmes in the country in several important areas such as genetic engineering, neurology and origin of life. He was closely involved in setting up of Sun Pharma Advanced Research Centre (SPARC) of Sun Pharmaceutical Industries Ltd. at Baroda. He has been scientific advisor and a member of the board of several pharmaceutical and biotechnological industries. He has been connected with a number of well-known social organisations, trusts and foundations. For example, he is a trustee of the Jagdish and Kamala Mittal Museum, of Indian Art, L.V. Prasad Eye Institute and L.N. Gupta Memorial Charitable Trusts, a member of the Governing Board of the Khorakiwala Foundation, and Chairman of the Governing Board of the Sanghi Centre for Human Resource Development.

He was founder-member of the Indian Society for Reproduction and Endocrinology, and foundation and foreign member of the Society for the Study of Reproduction (USA).

He has been a member of over 20 professional societies in India and abroad. He was President of the Society of Biological Chemists of India. He has been a member of the Nominating Committee of the International Union of Biochemistry, a member of the Council of International Cell Research Organisation (ICRO) and Federation of Asian and Oceanic Biochemists (FAOB) and President of the Indian Academy of Social Sciences. He is the President of the Association for the Promotion of DNA Fingerprinting and other DNA technologies.

He has been a member of over 50 major national committees such as the Science and Engineering Research Council, the Advisory Committee for Space Sciences, the Executive Council of Jawaharlal Nehru University, the Scientific Advisory Committee of the Department of Biotechnology, the Joint Working Group of the Indo-US Vaccine Action Programme, and the Scientific Council of the Indo-French Centre for the Promotion of Advanced Research.

He has been a member of the editorial and advisory boards of many well-known scientific journals including Molecular Biology and Medicine (UK), and Cellular and Molecular Biology (France).

He has received about 60 awards and honours. Most important of them are the following: Watumull Memorial Prize for Biochemistry (1962); the Padma Bhushan, from the President of India (1986); the National Citizen's Award of India (1988), D.Sc. from University of Burdwan (1988), the B.N. Chopra Award of the Indian National Science Academy (1989); the Prithvi Nath Memorial Award (1989); the Ranbaxy Research Award for Medical Sciences (1989); the SICO Award for Biotechnology (1990); Goyal Prize of Rs. 1,00,000 and a gold medal for research in biology (1993); the Rameshwardas Birla National Award of Rs. 1,50,000 for his contribution to medical sciences (1994).

He retired from the Directorship of CCMB in 1990 to accept the newly created position of a CSIR Distinguished Fellow from which he was relieved in February 1993. He has started "Anveshna Consultancy Services" at Tarnaka, Hyderabad.

METHODOLOGY

The choice of the unit of analysis has a strong influence on the measures and results of any bibliometric study. An up-to-date bibliography of publications of P.M. Bhargava (1947-1994) was compiled and considered to highlight the following quantitative aspects of his research communications : (i) authorship pattern, (ii) domainwise contribution, (iii) author productivity, (iv) use of channels of communication, and (v) documentation of keywords from titles of articles.

Normal count procedure [43] gives full credit to all contributors because each appearance of the author's name in the by-line is counted, regardless of whether he happens to be the first or the last author. If a scientist puts his name in a report he should have been directly involved in at least some part of it, contributing to either planning, analysing the study, or writing the paper.

The Collaboration Coefficient [44] in a domain is defined as the ratio of the number of collaborative research papers to the total number of research papers published in the domain during a certain period of time.

Productivity Coefficient [29] is defined as the ratio of 50 percentile age to the total productivity age.

Publication Density is defined as the ratio of the total number of papers published to the total number of journals in which the papers were published, and publication concentration is defined as the ratio in percentage of the journals containing half of the papers published to the total number of journals in which those papers were published during the period under study [45].

RESULTS AND DISCUSSION

During the period (1947-94) P.M. Bhargava published 128 research papers. Details of yearwise productivity, domainwise productivity, authorwise authorship credits, channels of communication used, number of pages per communication, and keywords in the titles are highlighted quantitatively.

1. **Yearwise Productivity**: The cumulative outputs of research papers of P.M. Bhargava are depicted in Fig. 1 with scientific progress indicator parameters such as: total publications, main author papers (i.e. single authored papers plus first authored papers in multi-authored papers), multi-authored papers, single author papers and collaboration coefficients in relation to time and age.

During the first decade (1947-56) of his publication career that is between the age of 20-29, all his publications were multi authored papers indicating the highest possible Collaboration Coefficient (1.00). Other periods with highest Collaboration Coefficients were 1952-56, 1958-59, 1961, 1965, 1969, 1971-73, 1976, 1979, 1982, 1984, 1987, 1992 and 1994 as he had published only multi-authored papers during these years. The overall collaboration coefficient during 1947-94 between 20-67 years age was 0.82.

The Publication Productivity Coefficient [29] was 0.58 indicating his higher productivity period just after 50 percentile age of his scientific research paper publication career under consideration.

It is said that mathematicians publish more in their early life and biologists work more in the middle of their careers. The Publications Productivity Coefficients for prominent Indian biologists were as follows: S.P. Agharkar (0.5), K.D. Bagchee (0.7), J.L. Bhaduri (0.4), F.R. Barucha (0.5), B. Bhatia (0.4), K. Biswas (0.3), J.J. Chinoy (0.6), B.K. Das (0.6), N.K. Panikkar (0.5), R.V. Seshaiya (0.3), J. Venkateswarlu (0.7), K. Ramiah (0.41), M.S. Swaminathan (0.45), C.S. Venkata Ram (0.5), L.L. Narayana (0.75), and U.R. Murty (0.65).

The general finding [46-49] was that scientists publish more frequently in the fourth decade of their life and thereafter their publication rate drops.

Zuckerman [50] compared the age distribution of American Nobel Laureates in science with the age distribution of American scientists in general. The majority of the Nobel Laureates were relatively young when they had made their prize-winning discoveries, but the majority of American scientists also were relatively young. Since the age distribution for Laureates matches with that for scientists in general, she concluded that when allowance is made for the number of scientists at different ages, younger scientists are less likely to be creative. However, due to their greater numerical representation, younger scientists are responsible for substantially more important contributions than older scientists. The issue of productivity and age is important to scientific endeavour. If productivity declines with age, then scientific capacity may be affected by an older age structure in science.

Lehman [51] found that the majority of discoveries in science have come from individuals below the age of 40. The peak age for achievements differed between disciplines, ranging from 26-30 for chemistry to 36-40 for genetics, geology, physiology and psychology. Scientists remain productive in the sense of publishing frequently beyond 40, but what they then generate was less likely to have impact. His general conclusion was that a genius does not function equally well throughout the years of adulthood. Superior creativity rises rapidly to a maximum which occurs usually in the thirties and then falls of slowly. Einstein was reported [52] to have said of scientists that "a person who has not made his great contribution to science by the age of thirty will never do so".

Prof. H.C. Brown, a Nobel Laureate, had done original work after his 70th year and long after winning the Nobel Prize and he still publishes 30 papers a year. Prof. Sir Neville Mott, one of the greatest minds in solid state science retired at 67 as Cavendish Professor at Cambridge. He then decided to pick a new problem and got a Noble Prize for that [53].

The "success breeds success" phenomenon has its limits [54]. A saturation takes place and instead of acceleration of the production rate, prolific authors are satisfied with their position and produce less than could be expected, as stated by Lotka's Law. Whereas Allison and Stewart [55] stated that the highly skewed distribution of productivity among scientists could be partly explained by a process of accumulative advantage. The publication productivity was found to be increasingly unequal as the career age increased.

Studies of stratification in science have increasingly accepted the idea that science is a highly stratified and elitist system with skewed distributions. Attempts to explain the higher productivity of higher status scientists by pointing to their greater ease of publication as far as acceptance of their work by journals and publishers is concerned were not supported by the data in some recent studies. Status in general does not confer greater ease of publication of the paper, [56] position within a research organization but does confer greater ease of author or co-authorship and this was the major explanation variable accounting for productivity difference within research laboratories as far as quantity of articles was concerned. Upward moves in a laboratory's formal or informal position hierarchy were associated with a change of a scientists' research involvement from goal-executing to goal setting functions as well as with an increasing access to scientific manpower and project money. Goal-setting tasks provided for a significant reduction of time expenditures in research necessary to assure that the scientists were identified with the research results; consequently, they allowed for an involvement in more research tasks than originally. Equivalent resources in scientific manpower and project money act as a multiplying element as far as quantity of output was concerned.

This agrees with various scholars who have noted a growing trend towards multiple authored scientific papers [57-63]. Later studies[64] found, instead of one peak the productivity of researchers was shown to have two modes. One before the age of 40 and the second around the age of 50. It was suggested that researchers may reach one type of plateau for innovative work and then, at a later stage, a second plateau for integrative work. Veteran R&D professionals will comprise those who devote most of their time to administration and those who are still active in technical work. The two mature types are basically similar in academic background and in their readiness to develop products, but they differ in their commitments to the scientific community and in the desire for greater extrinsic rewards [65].

2. **Domainwise productivity:** The domain wise quinquennial research paper productivity of P.M. Bhargava is provided in Table 1. He has published 15 papers (11.72%) in (a) organic chemistry and insecticides; 31 papers (24.22%) in (b) liver cell suspensions and uptake of nucleic acids; 18 papers (14.06%) in (c) cell division, malignant transformation, regulation of growth, concentration effect, cell cycle, and transport; 40 papers (31.25%) in (d) reproductive biochemistry; one paper (0.78%) in (e) mould metabolism; three papers (2.34%) in (f) tRNA and rRNA; four papers (3.13%) in (g) protein denaturation; one paper (0.78%) in (h) pyrimidine metabolism in *E.coli* seven papers (5.47%) in (i) evolution; five papers (3.91%) in (j) Antarctica microbiology; and three papers (2.34%) having (k) general perspectives.

He has published 22 papers during 1962-66 between 35-39 years of age, whereas 25 papers during 1982-86 between 55-59 years of age. He had a high productivity period during 1962-91 during which he had published 101 (78.91%) papers between 35-64 years of age. Therefore, these three decades were most productive. His 23 single authorship papers were published during 1957-91 over the period of 30-64 years of age.

He had 33 multiauthorship papers in the domain (d) reproductive biochemistry; 28 multiauthorship papers in the domain (b) liver cell suspensions and uptake of nucleic acids; 15 multiauthorship papers in domain (a) organic chemistry and insecticides; and 13 multiauthored papers in the domain (c) cell division, malignant transformation, regulation of growth, concentration effect, cell cycle, and transport.

Of his multiauthored papers five were in the domain (j) Antarctica microbiology, four in the domain (g) protein denaturation; and three were in the domain (f) tRNA & rRNA. He has published only one multiauthored paper each in the domains (e) mould metabolism and (h) pyrimidine metabolism.

He had both single authored as well as multiauthored papers in the domains (b), (c), (d) and (i).

The widening of P.M. Bhargava's interests with time can be visualised in Fig. 2. He published from 1947-55 in the domain (a); from 1962-84 in the domain (b); from 1955-88 in the domain (c); from 1957-94 in the domain (d); during 1962 only in the domain (e); from 1958-86 in the domain (f); from 1961-68 in the domain (g); during 1965 only in the domain (h); from 1978-90 in the domain (i); from 1988-92 in the domain (j); and from 1962-88 in the domain (k).

Fig.3 indicates domainwise authorship pattern. The highest two authored collaborations in 22 research papers were found in the domain (b) liver cell suspensions and uptake of nucleic acids; and 14 research papers in the domain (a) organic chemistry and insecticides. Twelve research papers were two authored and other twelve research papers were three authored in the domain (d) reproductive biochemistry. Eight authored papers one each were found in the domains (a) organic chemistry and insecticides, and (j) Antarctica microbiology.

He had seven single authored-papers in the domain (d) reproductive chemistry, and five single authored papers each in the domains (c) and (i). Three single authored papers each were in the domains (h) and (k).

3. **Authorwise Authorship Credits**: The collaborators with Bhargava, their period of association in publication, collaboration activity and their status in authorship in descending order of productivity has been presented in Table 2. P.M. Bhargava began his research career under the supervision and mentorship of A.B. Sen at Lucknow University and published[4] 11 papers in collaboration with him during 1947-50. He had also published 11 papers each with N. Shyamala Rao (1954-92) and S. Shivaji (1984-92). He had research collaborations with 76 contemporaries.

This research group had a total of 319 authorships. Single authorship were 23 (7.21%), two authorships were 118 (36.99%), three authorships were 75 (23.51%), four authorships were 44 (13.79%), five authorships were 25 (7.84%), six authorships were 18 (5.64%), and eight authorships were 16 (5.02%).

The collaboration is of two types: (i) Peer collaboration, which is with organizational equals having almost same status in knowledge and techniques; whereas (2) Hierarchical collaboration, is with organizational superiors, in status of knowledge, techniques, authority in a domain, and capability to write and get it published. However, it is a dynamic process having flux between the two. In the present case study P.M. Bhargava might have had hierarchical collaboration with A.B. Sen, C. Heidelberger, T.S. Work, C.A. Bornecque, and F. Zajdela. It should be noted that the term 'hierarchical' does not indicate official administrative position but it denotes expertise level in a particular domain at a given time. This kind of study needs further in depth analysis of actual efforts of individuals behind production of each and every paper which is not the aim of the present paper.

The names and authorship status of 37 collaborators of Bhargava who had two or more than two publications with him are provided in Table 2. Single collaborators, i.e., those who could publish only one paper with Bhargava were 39. A brief account of single collaborators follows: M. Lal was first author in two-authored papers; P. Vigier, A. Gambhir and Shanta S. Rao were the second authors in two-authored papers; S.V.S. Kashmiri, Shantoo Gurnani and P.K. Srivastava were first authors in three authored papers: R.R. Reddy V. Krishna Kumari, B. Gopinath, M. Arifuddin, T. Pallaiah, E.P. Allin, V. Dwarakanath, J.L. Simkin and H.I. Hadler were second authors in three authored papers: L. Montagnier and A.D. Taskar were third authors in three-authored papers; S.V. Bhide was first author in four authored paper; A.S. Kolaskar, K.C. Leibman and M.R. Das were second authors in four-authored papers; T.A. Thanaraj, E. Harbers and Annamaria Torriani were third authors in four-authored papers; V. Rukmini, M. Zimer and K. Jamil were second authors in five-authored papers: Ashok Khar and P.D. Gupta were third authors in five-authored papers; B.S.N. Reddy and G.L. Reddy were fourth author in five authored papers; V. Ramaswamy was fifth author in five authored papers; B. Singh was third author in eight authored papers; M.V. Jagannadham and I.K. Kacker were fifth authors in eight authored papers; and K. Ramachandran was sixth author; and V.D.N. Sastry was seventh author in eight authored papers.

The authorship productivity in

chronological order (year having first paper in collaboration with P.M. Bhargava) is plotted in Fig. 4. The group of three collaborators having 11 papers each and P.M. Bhargava with 128 papers formed one cluster of "Active Researchers". The second cluster of "Active Collaborators" having five to ten papers include eight researchers who had association with Bhargava during his most active research career. They are K.H. Scheit (1979-89), E.S.P. Reddy (1974-83), K.A. Abraham (1961-63), K.S.N. Prasad (1975-90), S.T. Jacob (1962-65), P.T. Iype (1963-65), G. Shanmugam (1965-71), and E. Prem Kumar Reddy (1970-83).

The third cluster of low productivity in collaboration with Bhargava include 67 authors having one to four papers. They are scattered throughout the publication productivity life of Bhargava.

Authorship productivity, i.e., the number of authors having the same publication productivity levels is provided in Fig. 5. The percentage of total authorships and cumulative percent in reverse order are also indicated.

It is a universal phenomenon that any research group is composed of only a few very active workers with enthusiasm and creative ideas, who keep up with the progress and various advances in science.

In Fig. 5, P.M. Bhargava can be compared to an engine pulling train compartments having passengers (researchers) who got associated and dissociated at their respective productivity destinations. Of course, in this case every researcher contributed his own capabilities and competence to the progress of the group.

An important requisite in any successful research system is the development of a pattern of interdisciplinary coordination within the scientific team so that it performs like a symphony orchestra. You may have a large number of research workers, each with a high degree of individual competence, but what is more important is the combined excellence of the whole group; as in the case of the symphony orchestra, the capability of the conductor is especially important for drawing out the best in each member of the team and for inculcating a spirit of pride in performance.

P.M. Bhargava had nurtured a contemporary collaborative culture. Indeed he was highly influential as a mentor [66].

Patrick Blackett was of the view that "A first rate laboratory is one where even mediocre scientists produce outstanding work".

The head of a department seems to be the most productive researcher. Firstly, it may be assumed that the most productive scientists become heads and secondly heads are 'owners' of almost all scientific results scored in the department headed by them [56,67].

Fox [68] summarised the following main factors influencing publication productivity of scientists: psychological characteristics, work habits, age, environmental location, and prestige of department or institution. She concluded that institutional prestige is one of the strongest correlates of publication productivity.

High status departments have the foresight to select those who will become productive and that the positions are allocated on the basis of potential (though not present) contribution [69].

It is obvious that authors publishing only one or a few papers during their lifetime can hardly contribute to the progress of science, naturally, and also not all publications of long-term authors contain a notable scientific contribution, but they "set the trend" on the development of science [70].

"The most important step in getting a job done is the recognition of the problem. Once I recognize a problem I usually can think of someone who can work it out better than I could". A page of Szillardisms included this thought on credit and fame: In life you must often choose between getting a job done or getting credit for it. In science, the important thing is not the ideas you have but the decision about which idea you choose to pursue. If you have an idea and are not going to do anything with it, why spoil someone else's fun by publishing it? [71].

A researcher is good if he or she surpasses the expectations of what he or she might achieve. The effectiveness of research or of running an institution depends primarily on the researcher himself, on his models and within the institute itself, on the respect he shows to his staff members, which, in turn, enables him to demand that they work to capacity [72].

The duty of scientists and technologists is not only to conduct their own work at the highest possible level of quality but also to make the society in which they live more aware of the powers and climate of science. Since, by definition, scientists and technologists are the first to know of scientific advances they can be described as the cartographers of the future. They must work to ensure that the public, and especially the public's leaders, understand the maps that they draw and the options that are available and sustainable, so that wise democratic decisions can be taken[73].

Nagpaul and Gupta [74] have concluded, after a study of 1460 research units in six countries, that professional competence is a necessity but not a sufficient condition for effective leadership: managerial competence is also required for effective leadership, but professional competence is much more important than managerial competence. This implies, inter-alia, that the quality of leadership cannot be improved merely through management development programmes. It would also be essential and desirable to improve the level of expertise of the leaders through a package of incentives like sabbatical leave to enable them to work at centres of excellence within or outside the country and by inviting leading scientists from such centres to work in the research institutions.

Notani [75] listed the problems of doing great science in India: (i) mastering of a particular field with identification of attendant deep problems awaiting elucidation, (ii) of think-alikeness and teamsmanship, (iii) access to new and first-hand information, and (iv) informed and objective criticism. Material support is required, of course, but the above mentioned requirements may be needed in equal measure.

Max Perutz, one of Britain's most distinguished scientists in his book "Is Science Necessary: Essays on Science and Scientists", states : "In Science, as in other fields of endeavour, one finds saints and charlatans, warriors and monks, geniuses and cranks, tyrants and slaves, benefactors and misers, but there is one quality that the best of them have in common, one that they share with great writers, musicians and artists: creativity". On the other hand there must be caution so as not to uphold orthodox scientists who are as adamant as religious fundamentalists on resisting new ideas destructive to some of their own pet theories and systems of thought. However, it takes belief in one's own ability and ideas, and courage to be a potential rising star and it takes a special kind of person like P.M. Bhargava to push out the frontiers of knowledge beyond the current state of the art.

"The creative scientist has much in common with artists and poets. Logical thinking and an analytical ability are necessary attributes to a scientist, but they are far from sufficient for creative work. Those insights in science that have led to a breakthrough were not logically derived from pre-existing knowledge: The creative processes on which the progress of science is based operate at the subconscious level" [76].

4. **Channels of Communication**: In the present study, 110 research papers were published in 47 journals: 11 papers were published in proceedings of symposia/ meetings; and 7 papers were published as chapters in books. Details are given in Table 3. The channel having the highest impact factor (22.139), immediacy index (5.224) and coverage in a number of abstracting and indexing periodicals (89). *Nature*, had published four research papers of P.M. Bhargava.

   Most frequently used channels were *Biochemical Journal* (U.K). *Journal of Indian Chemical Society* (India) and *Indian Journal of Biochemistry*, which was renamed from 1971 as *Indian Journal of Biochemistry and Biophysics*. In *Journal of Membrane Biology* (Germany) P.M. Bhargava has published six papers, having impact factor (4.017) and immediacy index (0.5), and coverage in 12 abstracting and indexing journals.

   Bradford's distribution [77-80] for research papers is provided in Table 4. A bibliograph (Fig 6) depicting frequency and cumulative number of research papers shows the pattern of distribution. Bradford's four zones (Table 5) indicated average Bradford multiplier as 2.31.

5. **Pages per Communication**: Domainwise range, mean and standard deviation of number of pages in research papers of P.M. Bhargava are given in Table 6. The articles having maximum (ten or more pages) were found in the domains b,c,d,f,g and i. Highest standard deviation (14.93) and coefficient of variance (116.01) was found in the domain 'Liver cell suspensions and uptake of nucleic acids'. His four papers having 20 or more pages are given below indicating their domain.

b. Preparation, properties and uses of single cell suspension from normal tissues. P.M. Bhargava. *Science and Culture*. 1968, **34 (Suppl.)**: 105-127.

c. Regulation of cell division and malignant transformation. A new model for control by uptake of nutrients. P.M. Bhargava. *Journal of Theoretical Biology*. 1977, **68**: 103-137.

d. A new pyrimidine-specific ribonuclease from bovine seminal plasma which is active on both single and double stranded polyribonucleotides and which can distinguish between Mg^{2+} containing and Mg^{2+} depleted naturally occurring RNAs. E.S.P. Reddy, K.H. Scheit, N. Sitaram and P.M. Bhargava. *Journal of Molecular Biology*. 1979, **135**: 525-544.

f. Aminoacyl - transfer RNA synthetase recognition codewords in yeast transfer RNAs: a proposal. P.M. Bhargava, T. Pallaiah and E. Prem Kumar. *Journal of Theoretical Biology*. 1970, **29**: 447-469.

6. **Keywords in Titles:** Keywords/ Phrases in the title of each paper were counted. The total keywords or keyword phrases, total number of words in the title are provided in Table 7. It is very clear that the titles of P.M. Bhargava's articles are very compact and highly expressive.

   Keywords from the titles of the articles were counted and those with frequencies more than three were included in Table 8.

   Keywords from titles of the articles having a frequency of two were : 1,2,5,6-dibenzanthracene-9; 10-C^{14}, 2-phenyl-phenanthrene; 3, 2-dicarboxylic acid; acid precipitation; acids; antibacterial; aromatic; biochemistry; biological; cell membrane: cellular composition: comparative: constitution: DNA: evidence: fertility; function; hepatic cells: immunological; *in vivo*; intercellular; labelled amino acids: plasma: preparation; pyrimidine: radioactive amino acids: reaction; relation; respiration; review: ribonuclease SPL. semen,: serum: sex glands: soils skin-protein-bound compounds: transition: trichloroacetic acids; variation: yeast: and zajdela ascitic hepatoma.

Keywords used only once in the title of the articles were: 2-acetoxybenzaldehyde, 3-chlorobutanone, 37°C, acid-soluble purine, acrosomal membranes, actinomycin D, activation, age, AIDS, albumin, alpha-halogenoketones, aminoacyltransfer RNA synthetase, analysis, antifertility factors, antimicrobial activity, antiseminalplasmin, arthrobacter, *Aspergillus terreus*, atypical behaviour, autolysis-defective mutants, bacterial, bacteriolytic activity, biochemical, biosynthesis, binding of urethan, BSI, buffalo, C^{14}-aminoacids, C^{14}-orotic acid, caltrin, *candida albicans*, cell cycle, cell surface ribonuclease, cell wall, chick chloramphenicol, chloroacetone, chromatographic separation, collagenase method composition, compounds, condensation, conditions, derivatives of 4, 4'-stilbenediol, digests, dry weight, EDTA, egg white, lysozyme, electrophoretic characteristics, embryo cells, enzyme, ether, ethyl melonate, exogenous RNA, Flexner-Joebling carcinoma, foreword, goat, guinea-pig, hamster cells, higher organisms, homologous, incubation, intercellular organisation, international congress, intracellular organisation, intracellular metabaolic activity, insecticidal activity, labelled arginine and glucose, levels of organisation, liver intestinal mucosa, liver microsomes, localization, logarithmically growing culture, lyses, macromolecular, mice, microbial, mode of action, malonic acid, *Micrococcus roseus*, molecular interactions, moscow, non-viral nucleic acids, nucleic acid precursor's, nucleotides, origin of life, partition, permeability controls, permeability properties, phenol, phenomenology, physiology, *Planococcus* spp., polyribonucleotides, positive role, premalignant liver, primitive cells, properties, *Pseudomonas* spp., psychrotrophic bacterium, pyruvate of fluoride inhibition, questions, rabbit, radioactive phosphorous, recognition code-words, regulatory mechanisms, regulatory pathways, reproduction, resistant to the lytic activity, reversal, reverse transcriptase, ribonucleolytic activity, ribosomal ribonucleic acid sequences, RNA-A, RNA polymerase, Rous sarcoma virus, salt, *S. cerevisiae*, secrete, seminal ribonucleases, seminar, solid hepatoma, soluble phase, solubility, solution, specificity, spermine, *Sphingobacterium antarcticus* sp. nov., substrate, symposium, thymidine, tissue specific recognition, transcription-inhibitory protein, transfer RNAs, transformation, transport, unilamellar liposomes, uracil-2-c^{14}, Uracil catabolic activity, urea, uses, utilization, volumes, what, why and yeast strains.

The results indicate that he had wide-ranging interests and superspecialization in the microthemes.

SUGGESTIONS

Two of his articles have received the highest citations out of more than 25,000 papers that have been published so far from the CSIR laboratories since the inception of the CSIR 50 years ago. The first paper is: A new method for the preparation of liver cells in suspension, S.T. Jacob and P.M. Bhargava, *Experimental Cell Research*, 1962, 27, 453-467. Today several hundred papers are being published on dispersed liver cells and various modifications of Bhargava's original techniques have contributed to several seminal discoveries in modern biology, including the discovery of some hormonal receptors. His second, most highly cited paper is: Uptake of non-viral nucleic acids by mammalian cells, P.M. Bhargava and G. Shanmugam, *Progress in Nucleic Acids Research and Molecular Biology* (Ed. W. Cohn and J.N. Davidson : Academic Press, New York, 1971, Vol. 11, Chapter IV, pp. 103-191).

Citation analysis of all of his publications till date need to be studied in order to know impact of his papers and citation life cycles for each and every paper. Outstanding cited papers can be identified. Such outstanding cited papers can be further studied to find out the context in which these papers were cited. Synchronous and diachronous citation rates should be found out.

Citation to each of his papers should be classified under: conceptual, operational, organic, perfunctory, confirmative, negational, and extraneous references (Books, Footnotes, Experimental papers, Private communications etc.) and analysed. Citations should be correlated with ratings of the scientists peers.

Every paper should be classified under one of the following categories:

1. Papers presenting primary findings (PF)

2. Papers presenting primary empirical evidence (PEE)

3. Papers presenting empirical reinforcements (ER); and

4. Non-contributing papers (NC)

This will enable in-depth understanding of his contributions

Scientists should not only publish scientific and scholarly research papers, but they are also to some extent expected to popularize and disseminate their research to the common man and to contribute to public debate. Communicating science is as important as creating it. P.M. Bhargava is one of the very few scientists in the country who has taken as much interest in the popularization of science and in discussing contemporary issues affecting science, scientists and society, as in doing hard science. He has published more than 150 articles in a variety of subjects outside hard science in well-known Indian and foreign newspapers, magazines and books. These need to be studied separately.

Annotated bibliography of all publications of P.M. Bhargava may be published.

Librarians have been invisible members of the science community for too long. Through the studies in the interdisciplinary domain of scientometrics they can show their visibility.

The librarianship profession should share the concern of educators, public servants, and scientists regarding the science literacy crisis [81]. To date, there has been relatively little written in the literature of librarianship about science literacy. The librarians have to play a potentially significant role in the promotion of science literacy.

Logopollution is caused by the production of information that cannot reach its potential users. It is dangerous because it makes useful or vital information unavailable. Factors that influence logopollution include message length, assimilation time, message efficiency and availability, message response, merit, and dispersal. Message packaging should assume new forms in order to reach the right recipient [82].

A very important purpose for an author is to write a paper for himself. Scientists still prefer to obtain their information by talking to other scientists. What they want from journal articles is not really information but stimulation towards creative thinking which will help them meet the challenge in their area of research [83].

The classic media for science publishing - journals put out by societies and other discipline-oriented organisations - were designed only for the specialists working in the same fields as that in which the findings were made [84].

Table 1: Domainwise quinquennial research paper productivity of P.M. Bhargava

Domain	a			b			c			d		e	f		g	h		i		j	k	Total						
	M		S	M		S	M		S	M		M	M		M	M	S	M		M	S	S	M		S+	S+	CC	Age of
Period	F	Co		F	Co		F	Co		F	Co	Co	F	Co	Co	Co		F	Co	Co			F	Co	F	M		P.M.B.
1947-51	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	10	-	11	1.00	20-24
1952-56	3	1	-	-	-	-	2	-	-	-	-	-	-	-	-		-	-	-	-	-	-	5	1	5	6	1.00	25-29
1957-61		-	-	-	-	-	-	1	1	3		-	1	-	1	-	-	-	-	-	-	1	4	2	5	7	0.86	30-34
1962-66	-	-	1	1	9	-	-	1	1		4	1	-	-	2	1	-	-	-	-	1	3	1	18	4	22	0.86	35-39
1967-71	-	-	3	1	7	-	-	1	-	-	-	-	1	-	1	-	-	-	-	-	-	2	2	9	4	13	0.85	40-44
1972-76	-	-	-	1	5	2	4	-	-	1	2	-	-	-	-	-	-	-	-	-	-	2	6	7	9	15	0.87	45-49
1977-81	-	-	-	-	-	1	1	-	2	1	4	-	-	-	-	-	2		-	-	1	6	2	4	8	12	0.50	50-54
1982-86	-	-	-	-	4	2	2	-	1	1	11	-	-	1	-	-	2	1	-	-	-	5	4	16	9	25	0.80	55-59
1987-91	-	-	-	-	-	-	1	-	2	-	4	-	-	-	-	-	1	-	1	4	1	4	1	9	5	14	0.91	60-64
1992-94	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	3	-	3	1.00	65-67
1947-94	4	11	3	3	25	5	10	3	7	6	27	1	2	1	4	1	5	1	1	5	3	23	26	79	49	128	0.82	20-67
Total papers	15			31			18			40		1	3		4	1		7		5	3		128					

a = Organic chemistry and insectiocides; b = Liver cell suspensions and uptake of nucleic acids; c = Cell division, malignant transformation, regulation of growth, concentration effect, cell cycle, and transport; d = Reproductivee biochemistry; e = Mould metabolism; f = tRNA & rRNA; g = Protein denaturation; h = Pyrimidine metabolism; i = Evolution; j = Antarctica microbiology; k = General perspectives; S = Single author; M = Multiauthor; F = First author; Co = Coauthor; and CC =

Table 2: Authorship status of P.M. Bhargava and his collaborators in descending order of Productivity

Sl.	Authorship		Two		Three			Four				Five					Six						Eight								Total	Period
No.	Scientists	S	I	II	I	II	III	I	II	III	IV	I	II	III	IV	V	I	II	III	IV	V	VI	I	II	III	IV	V	VI	VII	VIII	Authorship	FPY LPY
1.	P.M. Bhargava	23	13	46	8	3	14	4	-	-	7	1	-	-	-	4	-	-	-	-	-	3	-	1	-	-	-	-	-	1	128	1947-94
2.	A.R. Sen	-	10	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	1947-56
3.	N. Shyamala Rao	-	1	-	-	2	-	-	-	1	-	-	-	2	-	-	-	3	-	-	-	-	-	-	1	-	-	-	-	1	11	1954-92
4.	S. Shivaji	-	2	-	2	1	-	-	1	-	-	1	-	-	-	-	3	-	-	-	-	-	1	-	-	-	-	-	-	-	11	1984-92
5.	K.H. Scheit	-	1	-	2	1	2	-	1	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	1979-89
6.	E.S.P. Reddy	-	1	1	2	1	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	1974-83
7.	K.A. Abraham	-	6	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	1961-63
8.	K.S.N. Prasad	-	1	-	-	2	1	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1975-90
9.	S.T. Jacob	-	4	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1962-65
10.	P.T. Iype	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1963-65
11.	G. Shanmugam	-	3	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1965-71
12.	E. Prem Kumar	-	2	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1970-83
13.	G. Heidelberger	-	-	2	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1955-57
14.	S.A. Chandani	-	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1984-94
15.	G.S.N. Reddy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	1	-	4	1988-92
16.	L. Saisree	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	1	-	-	-	-	4	1988-92
17.	S.H. Zaheer	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3	1952-54
18.	T.S. Work	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1958-59
19.	B.V. Kumar	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1969-73
20.	N. Sitaram	-	-	-	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1979-92
21.	Veena N. Rao	-	1	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1980-85
22.	R. Sirdeshmukh	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1982-84
23.	D. Vijayarangam	-	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1983-92
24.	M.W.H. Bishop	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1959-59
25.	Kamalini Bhargava	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1962-68
26.	B. Thimmappayya	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1970-71
27.	M.A. Siddiqui	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1971-75

Sl.	Authorship		Two		Three			Four				Five					Six						Eight								Total	Period	
No.	Scientists	S	I	II	I	II	III	I	II	III	IV	I	II	III	IV	V	I	II	III	IV	V	VI	I	II	III	IV	V	VI	VII	VIII	Authorship	FPY	LPY
28.	L.E. [illegible]ssain	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1972-74	
29.	G. [illegible]i Kumar	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1975-75	
30.	C.A. Bomecque	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1975-76	
31.	D. Szafarz	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1975-76	
32.	E. Zajedela	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1975-75	
33.	M.W. Pandit	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1986-92	
34.	S.N. Chitnit	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1987-9[illegible]	
35.	Vipula Sheth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	1988-89	
36.	G. Seshu Kumar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	2	1989-92	
37.	M.K. Ray	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2	1989-92	
38.	T. Ramakrishna Murti	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1992-94	
1-38	Multiple Collaborators	23	58	56	22	16	23	10	8	8	11	5	2	3	3	4	3	3	3	3	3	3	2	2	1	1	-	1	1	2	280	1947-94	
39-77	Single Collaborators	-	1	3	3	9	2	1	3	3	-	-	3	2	2	1	-	-	-	-	-	-	-	-	1	1	2	1	1	-	39	1954-94	
1-77	Total	23	59	59	25	25	25	11	11	11	11	5	5	5	5	5	3	3	3	3	3	3	2	1	2	2	2	2	2	2	319	1947-94	

S = Single authorship; I = First Author; II = Second Author; III = Third Author; IV = Fourth Author; V = Fifth Author; VI = Sixth Author; VII = Seventh Author; VIII = Eighth Author; Single collaborator = Only one paper published by the Scientist in Collaboration with P.M. Bhargava. FPY = First Paper Year, and LPY = Last Paper Year

Table 3: Channelwise distribution of research publications of P.M. Bhargava

Sl. No.	Channels of communication	Paper No.	Paper %	Cumulative Papers	Cumulative %	Period of Usage FPY	Period of Usage LPY	Country of Publication	SCI-JCR 1992 Impact Factor	SCI-JCR 1992 Immediacy Index	Coverage in No. of A&I Journals
1.	Biochemical Journal	12	9.38	12	9.38	1958	1985	U.K.	3.716	0.583	44
2.	Journal of Indian Chemical Society	10	7.81	22	17.19	1947	1949	India	0.085	0.000	-
3.	Indian Journal of Biochemistry Continued from 1971 as Indian Journal of Biochemistry & Biophysics	10	7.81	32	25.01	1965	1988	India	0.328	0.031	25
4.	Journal of Membrane Biology	6	4.69	38	29.69	1975	1976	Germany	4.017	0.500	12
5.	Nature	4	3.13	42	32.82	1953	1979	U.K.	22.139	5.224	89
6.	Experimental Cell Research	4	3.13	46	35.95	1962	1970	U.S.	2.839	0.380	25
7.	Bioscience Report	4	3.13	50	39.08	1982	1988	U.K.	1.127	0.081	13
8.	Journal of the American Chemical Society	3	2.34	53	41.42	1955	1956	U.S.	5.298	0.964	-
9.	Journal of Scientific and Industrial Research	3	2.34	56	43.76	1961	1964	India	0.062	0.033	36
10.	Life Science	3	2.34	59	46.10	1962	1969	U.K.	2.053	0.339	10
11.	Biochimica et Biophysica Acta	3	2.34	62	48.44	1962	1994	The Netherlands	2.610	0.316	23
12.	Journal of General Microbiology	3	2.34	65	50.78	1965	1990	U.K.	2.034	0.315	39
13.	FEBS Letters	3	2.34	68	53.12	1981	1986	The Netherlands	3.505	0.490	40
14.	Journal of Chemical Society	2	1.56	70	54.68	1952	1954	U.K.	-	-	-
15.	Journal of Reproduction and Fertility	2	1.56	72	56.24	1963	1963	U.K.	2.211	0.315	17
16.	Journal of Theoritical Biology	2	1.56	74	57.80	1970	1977	U.K.	1.174	0.233	30
17.	Cellular and Molecular Biology	2	1.56	76	59.36	1979	1989	U.K.	0.705	0.125	13
18.	Current Science	2	1.56	78	60.92	1983	1983	India	0.253	0.075	46
19.	Japanese Journal of Biochemistry	2	1.56	80	62.48	1983	1985	Japan	-	-	-
20.	Jourla of Bioscience	2	1.56	82	64.04	1985	1988	India	0.383	0.077	16
21.	Polar Biology	2	1.56	84	65.60	1989	1989	Germany	1.159	0.231	5
22-47.	Journals having one paper each	26	20.32	110	85.92	1950	1992	-	-	-	-
48-58.	Proceedings of Symposium, one paper each	11	8.60	121	94.52	1961	1990	-	-	-	-
59-65.	Chapters in Books, one paper each	7	5.48	128	100.00	1970	1989	-	-	-	-

FPY = *First Paper Year*; LPY = *Last Paper Year*; SCI = *Science Citation Index*; JCR = *Journal Citation Report* and A&I = *Abstracting and Indexing*

Table 4

Bradford's scatter for research publications of P.M. Bhargava

C	CH	Σ CH	CH.C	Σ CH.C
1	44	44	44	44
2	8	52	16	60
3	6	58	18	78
4	3	61	12	90
6	1	62	6	96
10	2	64	20	116
12	1	65	12	128

C = *No. of communications or research papers*
CH = *No. of channels of communications*

Table 5

Bradford's zones for research publications of P.M. Bhargava

Zones	No. of papers	No. of journals	Bradford Multiplier
First	32	3	-
Second	30	8	2.67
Third	30	18	2.25
Fourth	36	36	2.00

Average Bradford Multiplier (δ) = 2.31

Table 6

Domainwise no. of pages in research papers of P.M. Bhargava

Domain	Range	Mean	SD
a	2-5	3.13	1.13
b	3-23	12.87	14.93
c	4-37	12.22	8.24
d	2-20	7.49	4.27
e	3-3	3.00	-
f	5-23	11.33	-
g	4-10	6.75	-
h	4-4	4.00	-
i	4-13	7.00	3.11
j	4-6	5.00	1.41
k	2-8	4.00	-

a = *Organic chemistry and insecticides* (N=15);
b = *Liver cell suspension and uptake of nucleic acids* (N=31);
c = *Cell division, malignant transformation, regulation of growth, concentration effect, cell cycle, and transport* (N = 18);
d = *Reproductive biochemistry* (N=40);
e = *Mould metabolism* (N=1);
f = *tRNA & rRNA* (N=3);
g = *Protein denaturation* (N=4);
h = *Pyrimidine metabolism* (N=1);
i = *Evolution* (N=7);
j = *Antarctica microbiology* (N=5); and
k = *General perspectives* (N=3)

Table 7

Kewords of keyword phrases in the titles of research papers of P.M. Bhargava

Domain	Total Keywords or keyword phrases	Total No. of words	Proportion of keywords to No. of words
a	42	92	1:2.19
b	166	388	1:2.34
c	94	278	1:2.96
d	232	525	1:2.26
e	3	9	1:3.00
f	12	37	1:3.08
g	18	46	1:2.56
h	4	12	1:3.00
i	23	75	1:3.26
j	24	54	1:2.25
k	8	16	1:2.00

a = *Organic chemistry and insecticides*;
b = *Liver cell suspension and uptake of nucleic acids*;
c = *Cell division, malignant transformation, regulation of growth, concentration effect, cell cycle, and transport*;
d = *Reproductive biochemistry*;
e = *Mould metabolism*;
f = *tRNA & rRNA*;
g = *Protein denaturation*;
h = *Pyrimidine metabolism*;
i = *Evolution*;
j = *Antarctica microbiology*; and
k = *General perspectives*

Table 8

Keywords frequencies in the titles of research papers of P.M. Bhargava

Keyword	Frequency	Keyword	Frequency
Suspension	21	Substituted dinitrophenyl Ketones	6
Protein(s)	18	Amino acids	5
Bovine	17	Antarctica	5
Rat(s)	17	Antimicrobial protein	5
Seminalplasmin	17	*In vitro*	5
Uptake	15	Ribonuclease	5
Liver cells	14	Schirmacher Oasis	5
Seminalplasma	13	Search for insecticides	5
Synthesis	13	Tissue(s)	5
Effect	12	Transcription	4
Spermatozoa	12	Chracterisation	4
Regulation	11	Identification	4
Cell division	9	Kidney	4
New	9	Mammalian	4
Cell(s)	8	Nutrients	4
Escherichia coli	8	Activity	3
Isolation	8	Comparison	3
Bull	7	Concentration	3
Evolution	7	Growth	3
Malignant transformation	7	Metabolism	3
Ribonucleic acid	7	Mg^{2+}	3
Chemical	6	Problem	3
Incorporation	6	Protein inhibitor	3
Inhibition	6	Seminal fluid	3
Liver parenchymal cells	6	Slices	3
Nucleic acid(s)	6	Structure	3
Phenyl-acetic acids	6	Translation	3
RNA synthesis	6		

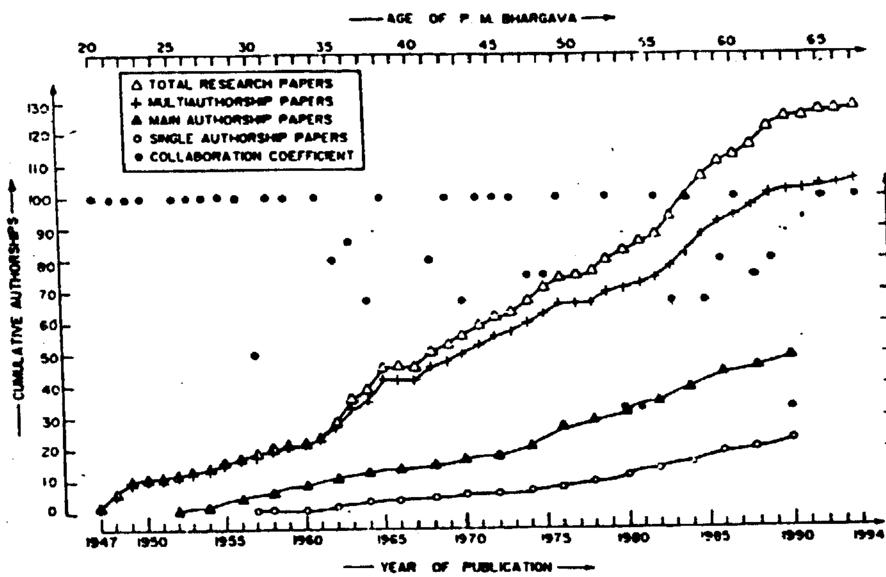

FIG. 1: YEARWISE RESEARCH PAPER PUBLICATIONS OUTPUT OF P. M. BHARGAVA

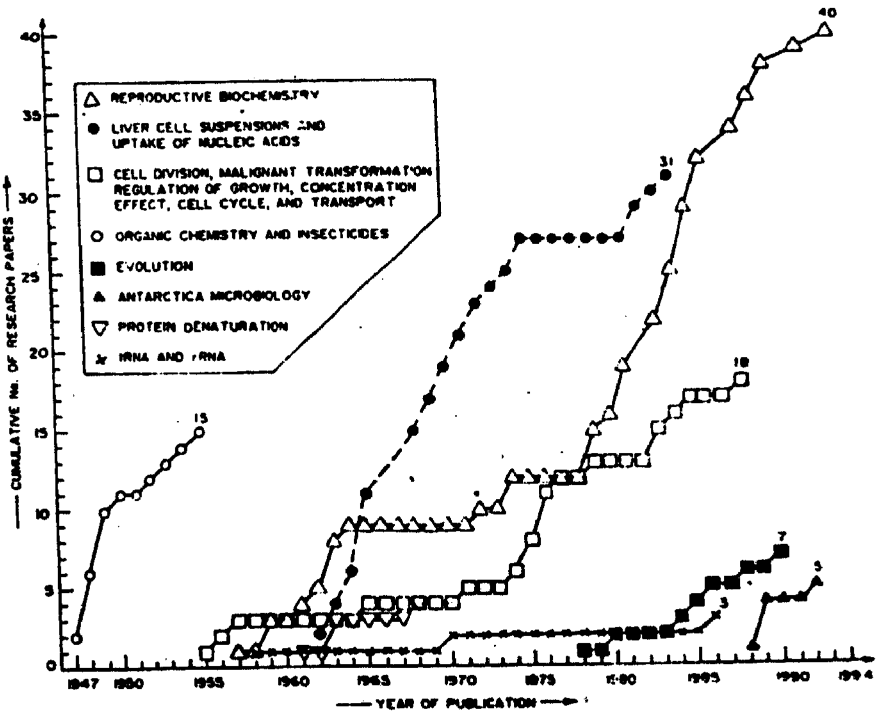

FIG. 2: DOMAINWISE GROWTH OF RESEARCH COMMUNICATIONS OF P. M. BHARGAVA

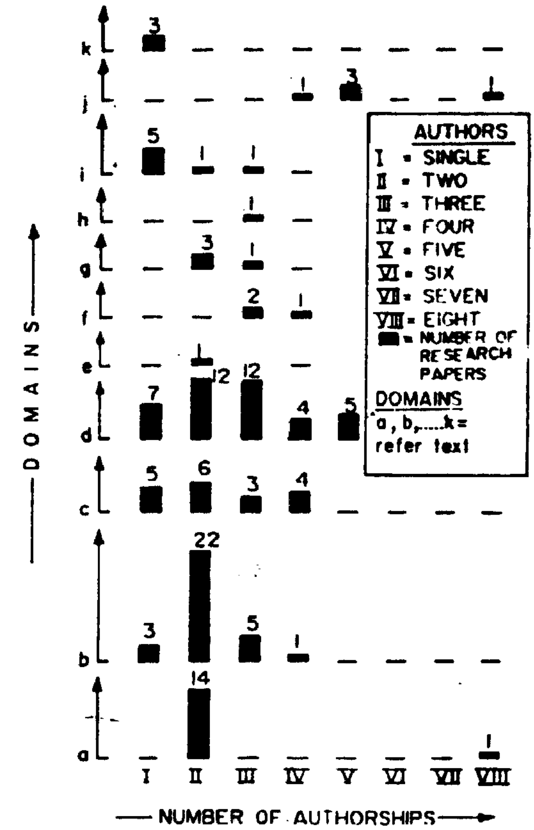

FIG. 3: DOMAINWISE NUMBER OF RESEARCH PAPERS AS PER AUTHORSHIPS

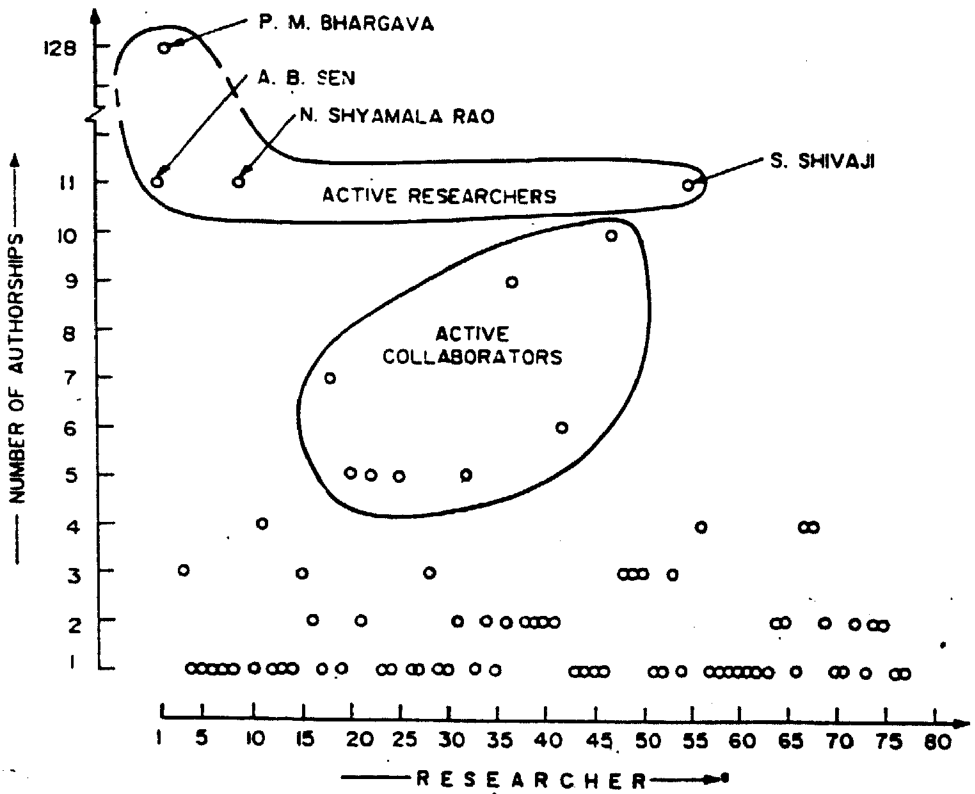

FIG. 4: RESEARCHERS ASSOCIATION WITH P. M. BHARGAVA IN CHRONOLOGICAL ORDER AND AUTHORSHIP CREDITS

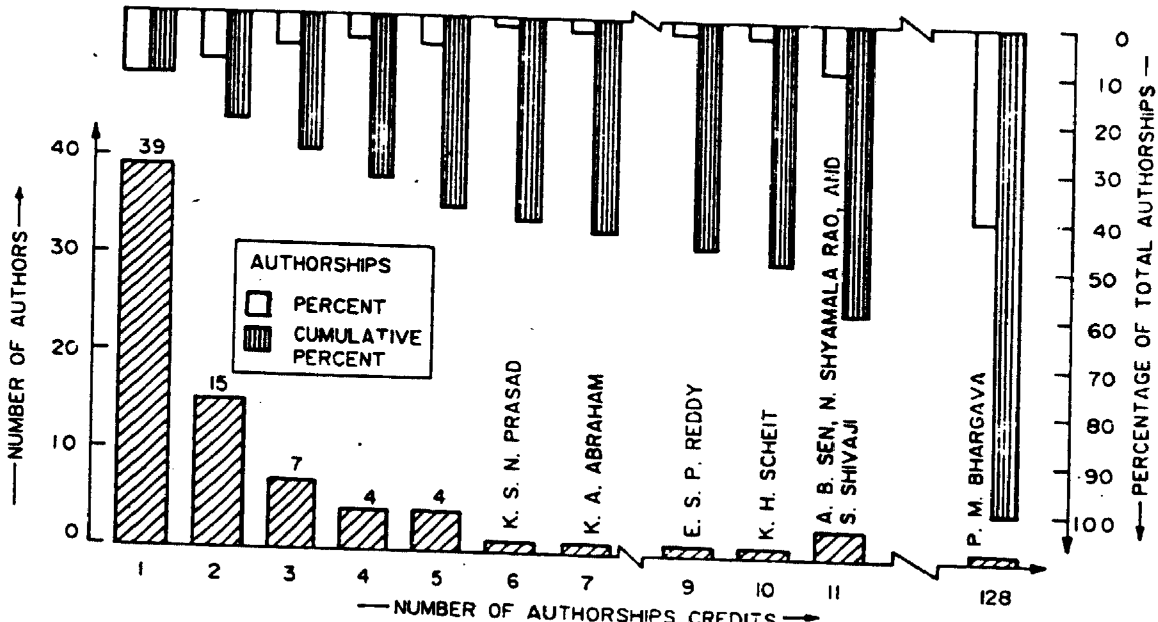

FIG. 5: AUTHORSHIP CREDITS TO RESEARCHERS COLLABORATING WITH P. M. BHARGAVA

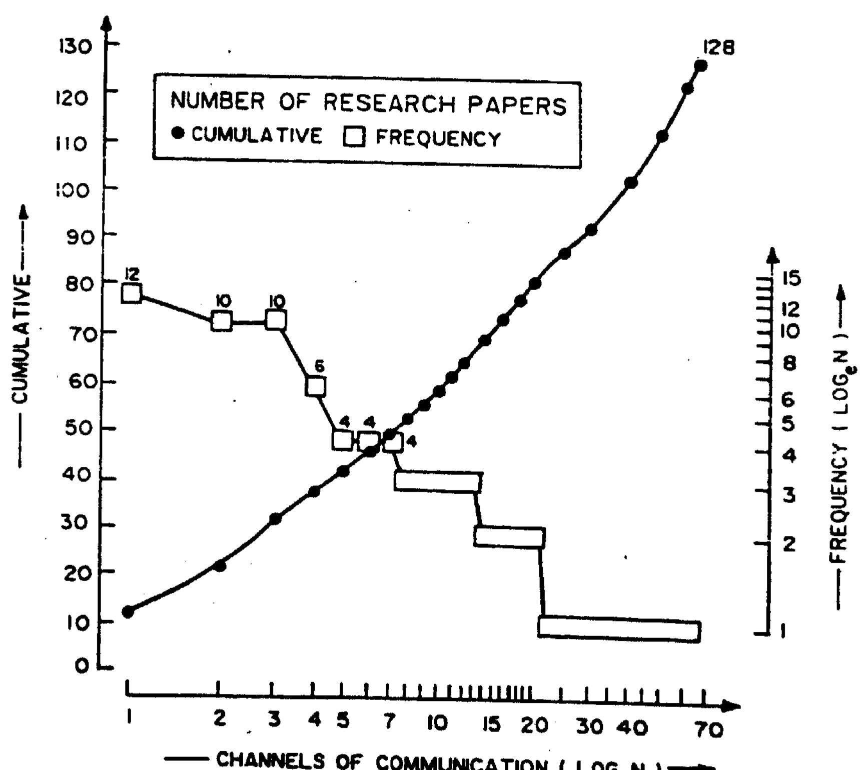

FIG. 6: BIBLIOGRAPH ON RESEARCH PAPERS OF P. M. BHARGAVA

CONCLUSION

Achievements of P.M. Bhargava in continuous publication productivity indicated his meritorious services to modern biology. He can be considered as a 'role model' for young researchers to follow. Knowledge is valuable for its own sake and research has a cultural value. The desire to be creative is built in our genes. Who knows these efforts may switch on genes for creativity in some of those who happen to read this article. Narrating success stories always has an encouraging effect. It is also important to recognize that excellence in science is not just a matter of a few individual successes. What is required is a wide base of high quality which would enable peaks to come up more frequently and on a more definite basis. New ways to motivate scientists seems as important to contest outcome as new sources of funds. Science policy makers, interested to know about functioning of active research teams as centres of excellence outputs, may find further interest in scientometrics. As per Indian Science Policy Resolution 1958, of which our scientists regard as their charter, "to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity" all of us must work together with holistic approach to accomplish synergistic progress.

There is no dearth of ideal rolemodel scientists in India. What we lack is a systematic and continuous study on such scientists. Hence, the comment "Most of the developing countries lack local 'role models' to motivate other scientists" [9] does not hold good at least for India.

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