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Research trends in select Science faculties of University of Jammu.

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Abstract

The study attempts to analyze and report research trends in various subject fields of the faculty of Sciences, Life Sciences and Mathematical Science of University of Jammu. The analysis is based on the data gathered from SCOPUS as on March-May, 2011. The data gathered were meticulously analysed to depict research trends in different Departments and Subject areas viz: collaboration at various levels, authorship patterns, and citation profile. The findings reveal that although the faculties under study have witnessed potential growth in terms of research output. However, several departments are still lagging behind in terms of productivity and quality research, which is evident from low research output and citation count received by the publications. Current study is confined to 1237 research contributions that were published during 39 years from (1972 to May, 2011), by the 15 departments under the faculty of Sciences, Life Sciences and Mathematical Sciences of University of Jammu indexed by SCOPUS. The study is beneficial to highlight potential areas of research and will act as a tool for addressing problems at research front in those subject areas where research output is very meagre.

Keywords– *Research, research output, Science and Technology research, Science and Technology research in India, collaborative research, University research, citation impact, research barriers.*

Introduction

Knowledge is being valued as a vital asset for progress and prosperity in every sphere of human understanding. The domain of knowledge especially scientific knowledge is ever expanding resulting out of experimentation carried out at different levels. This trend makes scientific & technological activities more important because it expands the intellectual asset of human kind and solves important national problems (**Yamamoto, 2001**). The most significant source of technological progress over the past several years has been the advancement of scientific knowledge. The dependence of industrial innovation on science first became evident in the last few decades of the 19th century. Industries the driving force of economy for a nation came to rely on universities to train the scientists & engineers that they would employ in their research. Therefore, University research itself also contributed to technical advances in industry all over the world (**Hill, 2006**). Science & technological research became the key area of focus because the engine of economic growth & social prosperity is the knowledge & the basic research that produces that knowledge. **Okafor and Dike (2010)** considers that the primary aim of research is discovering, interpreting, and the development of methods & systems for the advancement of human knowledge on a wide variety of scientific matters of world & universe. The results stemming from research & development can be used to solve various kinds of problems that are confronted by the society world over.

Modern day research is increasingly complex & demands an ever-widening range of skills. Collaboration is one way of addressing such demands. The science community has increasingly celebrated collaborative research and there has been growing importance of research collaboration in science community (**Gupta & Dhawan, 2008**). According to **He, Geng and Hunt (2008)** among the numerous benefits of research collaboration, often cited in literature are sharing knowledge & techniques, cross pollination of ideas, pooling research resources & sharing expensive instruments, increasing visibility & recognition and accelerating research progress.

Research, is regarded as an important indicator of nations competitiveness for the present and future (**Abbot & Doucouliagos, 2004**). Although govt. and private institutions have set up their own research centres and started their own research, universities continue to play a prominent role in knowledge production particularly in pure or basic research fields (Conroy, 1989); (Geuna, 1998); (Loon, 2008) as cited in (**Li, Millwater & Hudson, 2008**). The ultimate output of research in universities may come in different forms varying over time like scientific and technological information (**Mowery, n.d.**). Research output is a mean by which academics contribute their own knowledge to existing body of knowledge. These contributions are generally in the form of books, journal articles and reports (**Okafor 2011**). The generation, dissemination and applications of research outputs and findings are the basis for industrial innovations and improved productivity and competitiveness at the organizational, societal and national levels. Recognizing the immense importance of science and technology India, has built up a strong research and development base in both governmental and private sectors in all areas of science and technology. This has lead to an impressive quality of research publications. As reflected in the publications indexed in international multidisciplinary subject databases, India's publication growth rate has been relatively much faster in recent years (**Gupta & Dhawan, 2006**). So, a quantitative investigation of research publication, based on attributes like author, institutional affiliation, citation to papers etc which constitutes the research output are important for knowledge representation at the level of scientific speciality as well as for studying intellectual structures and also for understanding informal and formal collaborative networks in both natural and social science. Since research output measures the quantity of research in various fields, thus it can act as a bibliometric indicator. Bibliometric indicator seek to measure the quantity and impact of scientific publication as a proxy for overall output of research and are based on count of scientific papers and citations they receive. The most widely applied bibliometric indicator for research evaluation includes publication count and citation analysis (**King, 1987**). Analysis of publications provide some insight in to complex dynamics of research activity and enables policy makers and science administrators in framing policies and directions in which research and development (R&D) has to be conducted. Such

investigation is also important for systematic comparison of scientific output and for assessing status of Science and Technology across institutions especially universities.

Problem

Research plays an important role in underpinning a country's economic and social well-being. It plays a pivotal role in development of different subject areas and as such, much research is being contributed globally almost in every sphere of human knowledge (**Hill, 2011**). It holds true for Science and allied fields where research has become an index for measuring progress and development. In this context, university as centre of knowledge production and generation plays critical role in promoting science and technological research. Recognizing, the immense importance of university research, it becomes imperative to keep follow of trends in research to keep pace with current scientific and technological advancements. In this perspective, the present work attempts to analyze and report research trends in various subject fields of the faculty of Sciences, Life Sciences and Mathematical Science of University of Jammu.

Scope

The present study attempts to explore and analyse the research contributions of University of Jammu from 1972- May 2011 , in the faculties of Sciences, Life Sciences and Mathematical Science indexed through *Scopus*-one of the world's largest indexing and abstracting services.

Objectives

The objectives of the study are

1. To explore the research output in the faculties of Sciences, Life Sciences and Mathematical Science.
2. To reveal the research trends in various subjects and allied departments.
3. To analyze the overall citation pattern.

Methodology

The present study is based on the data collected from *Scopus*, one of the largest abstracting and indexing service in the world (**Scopus, 2011**). Publications of researchers affiliated to

University of Jammu and belonging to the faculties of Sciences, Life Sciences and Mathematical Science were harvested using "Affiliation Search". Research contributions from 15 departments under the above-mentioned faculties are collected and analysed to reveal research trends viz: productivity, collaboration at various levels, authorship patterns, and citation profile etc revealed by different Departments and Subject areas.

Review of Literature:

Several studies have been conducted to bring to light the role and importance of scientific research in overall progress of modern society .This section reviews several studies conducted to assert the status of scientific research.

Gottlieb (n.d.) states that modern society is literally built on science and technology (S&T). Since, Science & technology (S&T) together are closely associated with our lives as they are strongly linked aspects of our society, so the development in both science & technology are essential for overall progress of society. Further, commenting upon the concept and purpose of Science the author emphasis that Science is an intellectual activity carried on by humans that is designed to discover information about natural world in which humans live & to discover the ways in which this information can be organised in to meaningful patterns. The primary aim of science is to collect facts (data) & an ultimate purpose of science is to differentiate the order that exists between & amongst the various facts. **Shuttleworth, (2008)** is of opinion that research is the cornerstone of any science including both hard science such as chemistry & physics & social (or soft science such as psychology, management & education). Research is very much important in order to continue with the development of Science and Technology, to make path for innovations, to increase knowledge as well as to improve the existing knowledge. Another study by **Teferra, (2004)** reveals that in the broadest sense of the word, the definition of research includes any gathering of data, information & facts for the advancement of knowledge. Moreover, **Moed, (2009)** in his study revealed that in present day world, scientific & technological discoveries have become an index for measuring the social, political & economic well-being of a nation. Research in science and technology is of great importance and key to progress towards a knowledge-based, or an innovation- driven economy. It promotes better understanding on different aspects of life and helps to improve the standard of living by

creating new knowledge and technological innovations. Analysis of these forces & evaluation of quality & quantity of scientific research are indispensable in national science policy or research management strategy.

Li, Millwater and Hudson (2008) in their study divulged that a nation's overall capacity depends considerably on its research. It is widely accepted that research is the most important source of knowledge generation and occupies a critical position in promoting nations prosperity and its citizens well being in knowledge based era. Furthermore, the study revealed that knowledge society depends for its growth on the production of new knowledge, its transmission through education and training, its dissemination through information and communication technology and on its use through new industrial process or services. Universities play a key role in all these three fields of research and exploitation of its results. Especially in the developing countries, universities have to play an active role in transforming traditional society into the modern information society or knowledge society. **Siemens and Matheos, (2010)** are of opinion that universities have the social responsibility for generating specific, technical and skilled work force required for the society. They have a major role in information generation since a major part of scientific and technical publications are from the universities. Thus, Universities being the centres of knowledge production and generation plays important role in the national research. Another study by **Yamamoto, (2001)** revealed that research particularly in science has long been seen as a vital function of universities. The research universities play an important role as a source of fundamental knowledge and occasionally, industrially relevant technology in modern knowledge based economies. Today Science and Technology contributes to our society and economy much more than before. Consequently, science and technology is expected to be the engine that drives the reform of socio-economic system through research, which is the wellspring of knowledge. The production of new knowledge through the practice of research lies at the heart of universities mission. **Ochai and Nawfor, (1990)** in their study highlighted that the outcome & extent of functions of the academics in creating new knowledge & innovation are forms of research output. Research output is a mean by which academics contribute their own knowledge to existing body of knowledge. This can be in the form of journal articles, technical report & books. The publishing

of research findings is also an act of information transfer between producers and consumers of information and knowledge. Academics place emphasis, on research & publication, not only because it is presumed that research enriches teaching & learning process, contributing to the body of knowledge but also because it is a major determinant of institutions prestige. Furthermore, universities are viewed as a bastion of learning and knowledge creation. They play a decisive role as a source of intellectual property and talent in regional development and high technology industries. Industries the driving force of economy for a nation came to rely on universities to train the scientists and engineers that they would employ in their research. Thus, University research itself also contributed to technical advance in industry (**Hill, 2006**). The publications contributed by the researchers from different faculties of a particular institution constitute the research output of that institution. Since research output measures the quantity of research in the various fields, thus it can act as a bibliometric indicator. Since, Bibliometric indicator seek to measure the quantity and impact of scientific publication as a proxy for overall output of research and are based on count of scientific papers and citations they receive . The most widely applied bibliometric indicator for research evaluation includes publication count and citation analysis (**King, 1987**). Bibliometric indicators are especially important for researchers and organizations, as these measurements are frequently used in funding decisions, appointments and promotion of researchers and evaluation process at universities and other research institutions. Thus, bibliometric indicators are becoming increasingly important.

Gupta and Dhawan (2006) highlighting the status of scientific research in India reveals that India, has built up a strong research and development base in both governmental and private sectors in all areas of science and technology. As reflected in the publications indexed in international multidisciplinary subject databases, India's publications growth rate has been relatively much faster in the recent years. India's publications indexed in Web of Science have grown from 14405 papers in 1990 to 28603 papers in 2005. India tops in publications productivity among developing countries in four subject fields, based on its cumulative publications output during 1993-2003. Its rank in world's publications output and percentage- wise contribution in each subject is as follows: Agriculture (4th, 5.63%), Plant & Animal Sciences (8th, 3.13%), Energy & Environmental Sciences

(11th, 1.97%) and Biology & Biochemistry (14th, 1.51%). It ranked 2nd in publications productivity amongst developing countries, following China in Materials Science (8th, 3.56%), Chemistry (8th, 3.62%), Physics (9th, 2.26%), Geosciences (11th, 2.31%), Pharmacology & Toxicology (13th, 1.89%), Space Sciences (13th, 1.55%), Mathematics (8th and 3.56%), Molecular Biology & Genetics (19th and 0.76%), and Immunology (20th and 0.7%). It ranked third in Engineering (11th and 2.39%) and Microbiology (17th and 1.42%). India ranks at 13th position among the top 24 countries in computer science, with its global publication share of 1.72% during (1999–2008) **(Gupta, Kshitij & Verma, 2010)**. As far as productivity is concerned, the fields of chemistry, physics and engineering are high productive areas of science and technology research. However, agriculture, biology, basic life science, clinical medicine, bio-medical science and earth environmental science have been the medium productivity areas whereas mathematics and computer sciences have been the low productivity areas of Indian science and technology research **(Gupta & Dhawan, 2008)**.

¹Analysis:

1. Journal distribution

Scopus has indexed contributions of the University of Jammu from 160 distinct titles. Among these, researchers mostly preferred the journal - *Physical Review C: Nuclear Physics*, in which 60 publications got published. *Physical Review Letters* and *Journal of Chemical Crystallography* followed the list with 52 and 33 publications respectively. Table 1 enlists the top 10 journals used by the researchers of University of Jammu in the faculties of Sciences, Life Sciences and Mathematical Science and among these, only four titles are published in India and the rest six are foreign publications.

¹ Formulae used :

a) Average citations per paper

Av. Citations/paper = Total citations won by a given set of papers / Total no. of papers in a given set

b) Compound annual growth rate (CAGR)

$$\text{CAGR} = \left[\frac{\text{Ending value}}{\text{starting value}} \right]^{1/(\text{number of years})} - 1$$

c) Growth rate (Percent change)

$$\text{Growth rate} = \left[\frac{\text{Value at end of period} - \text{Value at beginning of period}}{\text{Value at beginning of period}} \right] * 100$$

Table 1: Top 10 Journals used by the researchers

Rank	Title	No. of publications
1	Physical Review C Nuclear Physics	60
2	Physical Review Letters	52
3	Journal of Chemical Crystallography	33
4	Physics Letters, Section B: Nuclear Elementary Particle and High Energy Physics	28
4	Journal of the Indian Chemical Society	28
5	Journal of the Geological Society of India	26
6	Materials Chemistry and Physics	22
6	Journal of Materials Science	22
7	Indian Journal of Pure and Applied Physics	21
7	Current Science	21

2. Type of Sources used

Of the total 1237 publications, 1219 publications appeared in Journals, 12 in Conference Proceedings, 4 in book series, 1 each in Book and Trade Journals (Table 2).

Table 2: Type of sources preferred by the Researchers

Source Type	No. of publications
Journals	1219
Conference Proceedings	12
Book Series	4
Books	1
Trade journals	1
TOTAL	1237

3. Type of Publications

From Table 3 it is clear that of the total 1237 publications published during the study period, 1132 publications are Research Articles, 36 Conference Papers, 14 publications each as Notes and Review Articles, and a meagre no. of 6 as Letters. However, nature of 23 publications could not be ascertained and have been categorized under Unknown.

Table 3: Types of Publications
N = 1237

Rank	Document Type	Count
1	Research Articles	1132 (91.59)
2	Conference papers	36 (2.91)
3	Notes	14 (1.13)
4	Review Articles	14 (1.13)
5	Articles in press	12 (0.97)
6	Letters	6 (0.49)
	Unknown	23 (1.86)

** Figures in parentheses indicate percentage*

*** Total percentage does not equal 100% due to rounding off*

4. Decade wise Growth

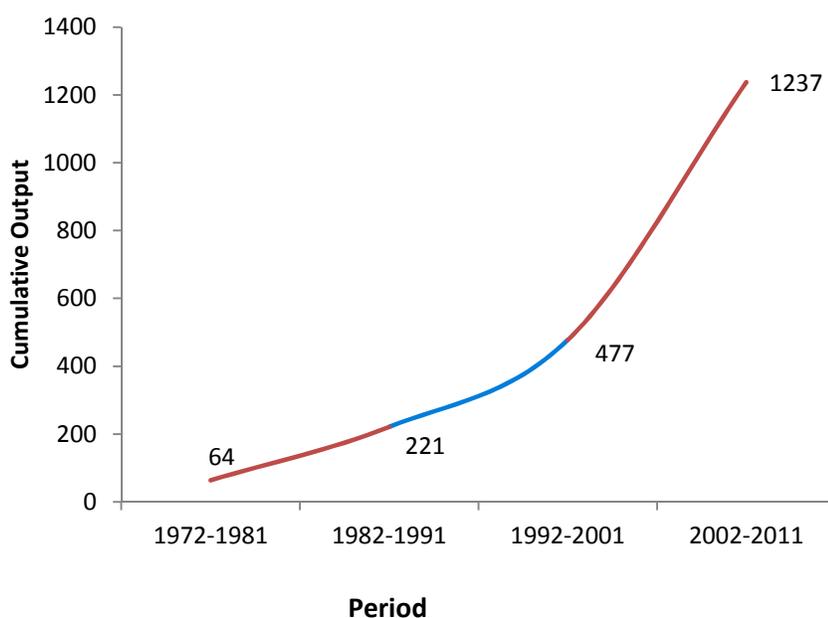
The 39 years study makes it evident that research activities at University of Jammu shows Compound Annual Growth Rate (CAGR) of 7.89%. While comparing its contributions made in two successive decades, the growth rate is maximum during the period 2002-2011 and minimum during 1992-2001. (Table 4, Fig 3)

Table 4: Decade wise publication output from the faculty of Sciences, Life Sciences and Mathematical Science

Period	Output	Cumulative Output	Growth Rate
1972-1981	64	64	-

1982-1991	157	221	145.31%
1992-2001	256	477	63.05%
2002-2011	760	1237	196.87%

Fig. 3: Decade wise Growth of research contribution



5. Research Output of Departments

1237 publications are contributed by 15 different departments of University of Jammu. Table 5 shows the ranked list of the contributions of various departments. Department of Physics & Electronics tops the list with 527 publications (42.6%), followed by the departments of Chemistry and Geology with 331 (26.76%) and 103 (8.33%) publications respectively. On the other extreme, the least productive departments are Human Genetics and Biochemistry, which contributed a meagre no. of three and one publications respectively. It is also evident from table that only three departments have contributed more than 100 publications and five departments above 50. Moreover, if the authors of the publication are from different departments, the publication was counted under each of them.

Table 5: Research Output of the faculties of Sciences, Life Sciences and Mathematical Science

N = 1237

Rank	Department	Output
1	Physics & Electronics	527 (42.6)
2	Chemistry	331 (26.76)
3	Geology	103 (8.33)
4	Bioscience	61 (4.93)
5	Mathematics	54 (4.37)
6	Biotechnology	48 (3.88)
7	Botany	41 (3.31)
8	Zoology	26 (2.10)
9	Environmental Science	14 (1.13)
10	Statistics	12 (0.97)
11	Home Science	7 (0.57)
12	Geography	5 (0.40)
13	Computer Science	4 (0.32)
14	Human Genetics	3 (0.24)
15	Bio-chemistry	1 (0.08)

** Figures in parentheses indicate percentage*

*** Total percentage does not equal 100% due to rounding off*

6. Research Output and Impact under Broad Subject categories.

Table 6 shows the ranked list of the contributions of 16 subject areas of 3 faculties as defined by *Scopus* classification during 1996-2011. Among various subjects Physics & Astronomy tops the list with 477(25.58%), followed by Chemistry and Material Science with 363 (19.46%) and 176 (9.44%) publications respectively. On the other extreme, the least productive subject areas are Immunology & Microbiology and Energy, which contributed a meagre no. of 12 and 9 publications correspondingly. Moreover, if the subject of publications is covered under different journals, the publication was counted under each of them. Table 6 also reveals Physics

and Astronomy ranked top in terms of average citations, which recorded on average 13.67 citations per paper. However, Energy witnessed least no. of 0.22 citations per paper.

Table 6: Contribution and performance of different subject areas

Rank	Subject	Output	Total citations	Average citation /paper
1	Physics & Astronomy	477	6521	13.67
2	Chemistry	363	1570	4.33
3	Material Science	176	786	4.47
4	Biochemistry, Genetics &Molecular Biology	162	772	4.77
5	Agriculture and Biological Science	147	543	3.69
6	Earth and Planetary Science	101	342	3.39
7	Pharmacology	86	495	5.76
8	Mathematics	74	197	2.66
9	Environmental science	69	140	2.03
10	Engineering	52	219	4.21
11	Chemical Engineering	43	211	4.91
12	Multidisciplinary	35	120	3.43
13	Medicine	28	63	2.25
14	Computer Science	19	21	0.68
15	Immunology and Micro Biology	12	46	3.83
	Energy	9	2	0.22

7. Profile of Authorship Pattern of contributions of the faculties of Sciences, Life Sciences and Mathematical Science.

It is clear from Table 7 that 96.69% of publications are co-authored (1196). The highest alliance has taken place among more than three authors, which constitutes 49.31% of the total. The least coalition is found in the team of two authors 23.2%.

Table 7: Authorship pattern of contributions of the faculties of Sciences, Life Sciences and Mathematical Science

N = 1237

Pattern	No. of publications
Single Author	41 (3.31)
Two-author	287 (23.2)
Three -Author	299 (24.17)
>3 Author	610 (49.31)

** Figures in parentheses indicate percentage*

*** Total percentage does not equal 100% due to rounding off*

8. Profile of Collaborative Research from the faculties of Sciences, Life Sciences and Mathematical Science.

Collaboration pattern of publications from the faculties of Sciences, Life Sciences & Mathematical Science; University of Jammu has been categorized into four categories viz., Local, Regional, National and International. The findings reveal that the highest share of (1031, 54.69%) publications is contributed through local collaboration while as the least share of (102, 5.41%) publication is contributed through Regional collaboration.

Table 8: Collaborative Research from the faculties of Sciences, Life Sciences and Mathematical Science

Level	Total
Local	1031 (54.69)
National	420 (22.28)
International	332 (17.61)
Regional	102 (5.41)

** Figures in parentheses indicate percentage*

*** Total percentage does not equal 100% due to rounding off*

Findings and conclusion

High quality, academic research output in an institution craft a knowledge hub and motivates the faculty and students to cater a learning environment par excellence. In all, 1237 research contributions were published during 39 years study period (1972 to May 2011), by the 15 departments under the faculty of Sciences, Life Sciences and Mathematical Science of University of Jammu.

The main findings of the study can be concluded under the following major headings:

Growth in Research output

The research activity of university of Jammu in the faculty of Sciences, Life Sciences and Mathematical Science is accelerating both in terms of growth rate and in terms of quality of publication output. Of various departments under these faculties, the maximum contribution of (527 papers) has been witnessed from Physics & Electronics and least contribution of (one paper) from Biochemistry. The cumulative publication of the faculty of Sciences, Life Sciences and Mathematical Science has increased from 64 – 1237 showing a growth rate of 1832.81 %.

Quality of research

Among the various subject areas Physics and Astronomy has highly cited papers with 6521 citations followed by chemistry with 1570 while least cited papers are that of energy with only 2 citations which makes it evident that Physics and Astronomy contributes quality research papers than other subject areas. Since, Citation counts for research papers provide an indicator of the quality and impact. It has been extensively acknowledged that the number of times a paper is subsequently referred to or 'cited' is a reflection of its 'impact' on related work. Therefore, a citation count reflects impact, higher impact reflects higher quality, and impact indices become a proxy for relative performance or excellence (**Adams, Gurney & Marshall, 2007**).

Collaboration

Collaborative research plays a significant role in influencing the quality and quantity of research output in any country or an organization as scientific collaborations affects the quality of papers, since it is possible to share knowledge and techniques in real time (**Gupta and Dhawan, 2006**). Thus, Collaboration is encouraged at a policy level because it provides access to a wider range of facilities and resources. Moreover, collaboration provides opportunities to move further and faster by working with other leading people in their field. It is therefore unsurprising that collaborative research is also identified as contributing to some of the highest

impact activity (**Adams, Gurney & Marshall, 2007**). Present study also reveals that the authors prefer to work in collaboration at various levels which clearly indicates that they are well conversed with the benefits of collaboration. Of the various types of collaboration the share of local (within institution) collaborative papers is maximum (54.69%), followed by national (22.28%) and international (17.61%) collaboration respectively. Least share of contribution comes within regional (State) level collaboration (5.51%). Thus, suggesting that the researchers prefer to collaborate within the institution and provide least preference to regional collaboration.

Authorship

Glanzel and Schubert (2004) commented that share of single –authored papers in all subject field have rapidly decreased from 15% -10% during the period 1980-2000. Consequently, nowadays-average paper has more than four co-authors. Accordingly, Current study also reveals that maximum contributions of research publications are with more than three authors, followed by three-authored publications, as Researchers prefer to work as a team. Since, the publication having two or more authors are highly cited as revealed in a study conducted by (**Shari, Haddow & Genoni, 2012**).

Performance

Gupta and Dhawan (2006) highlight that Physics, chemistry, and basic life sciences were the dominating areas of research. Similar findings are revealed from the current study, which states that in terms of both quantity as well as quality; Physics & Astronomy and Chemistry are the high productivity research areas in the three faculties of University of Jammu. On the other hand, Environmental science and Mathematics are the medium productivity research areas while as Energy and Immunology & Microbiology are the low productivity research areas in terms of no. of publications contributed by each subject area.

Thus, the key factors for improving quality and catalyzing growth in research has been identified as greater institutional participation in research and greater collaboration. However, there is a strong and urgent need to evolve new and effective strategies to improve research productivity in low and medium productive areas.

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