Qualitative and Quantitative Methods in Libraries (QQML) 11,2:361-384 ,2022

A Quick Perusal of Scholarly Profile of Nobel Laureates in Chemistry Discipline based on h-Index (Hirsch Index) Using Scopus Database

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Abstract: This paper uses the h-index for the perusal of the profile pictures of researchers who have been awarded the Noble Prize in Chemistry from 1901 till 2021. In the present study, the publication data of 49 Nobel Laureates in the Chemistry discipline has been analyzed where the citation data from the Scopus database is considered. The h-index has been preferred to the impact factor and other Scientometric metrics because of their selective coverage and the disadvantages that researchers publishing several papers face. The Scopus database has been preferred over Google Scholar and Web of Science (WoS) as the source of data for this particular study because it is more popular among researchers. The present paper is an attempt to examine the profile of Nobel Laureates in the Chemistry discipline since the inception of the awards till 2021 using the h-Index (Hirsch Index) using data available in the Scopus database. The study is unique in itself as to the best of our knowledge it is the first attempt at creating a profile of Nobel Laureates using the h-index in any discipline and the study will open the path for scholars to conduct further research in this particular area.

Keywords: Scholarly Communication, h-index, Citations, Nobel Laureates, Chemistry, Scopus, WoS, and Google Scholar

Received: 1.4.2022 Accepted: 24.6.2022 ISSN 2241-1925

1. Introduction

Nobel Prize is a set of five awards in five different subjects: Chemistry, Literature, Medicine, Peace, and Physics which are presented to individuals every year for outstanding contributions to humanity. These prizes are awarded in terms of the will of Alfred Nobel dated 1895. Economic Sciences has been added to the list of prizes in 1968. Named after Alfred Nobel, a Swedish chemist, and engineer, the Nobel Prize is being awarded annually since 1901. The recipients of the Nobel Prize are called Nobel Laureates, and each Nobel Laureate is entitled to a gold medal, a citation, and a monetary award calculated at US$1,145,000 in 2020. As per the will of Alfred Nobel, the number of recipients should not exceed three persons in any given discipline [1]. The Nobel Prize is not awarded posthumously, but, if any recipient dies after the announcement of the award, the prize is awarded to the relatives or the institution which the author represented [2]. With the Nobel Prize in the five disciplines being awarded since 1901 and in Economic Sciences since 1969, Nobel Prizes have been awarded 603 times. Today, we have 962 Nobel Laureates while 25 organizations have also been conferred the Nobel Prize. Four persons have been awarded the Nobel Prize on more than one occasion [3]. This study looks at the scholarly profiles of Nobel Laureates in Chemistry using the Hirsch Index which finds wide usage in scientometric studies. The concept/study of Scientometric, as we know it today, bases itself on the works of Derek J de Solla Price and Eugene Garfield. Garfield has made an immense contribution to the field of Scientometric by way of creating the Science Citation Index and is also credited with establishing an academic journal dedicated to scientometry. The journal was named Scientometrics and the first edition of the journal was published in 1978. Scientometrics lays its focus on measuring the outputs of the researchers and is different from other fields like sociology which bases itself on understanding the behavioral patterns of the scientists. Scientists or Nobel Laureates or experts in any domain of knowledge are known for their level of expertise in certain fields and their contribution to the betterment of society. These people contribute by way of producing scientific papers or publications that enrich any domain of knowledge. The Scientometric analysis includes qualitative and quantitative techniques. These techniques find utility in understanding the outcome of any researcher and the level of impact that they have on society.

2. Brief about Chemistry

Chemistry is that branch of science that deals with the properties, structure, and composition of all matter and also covers the changes these matters undergo when they react with other matters [4]. As a subject, the scope of Chemistry lies between biology and physics and provides a basis for an understanding of both

sciences at a basic and an applied level [5]. It is, therefore, referred to as the *central science* [6]. At a rudimentary level, Chemistry explains how new compounds are formed due to the combining of atoms and molecules. Going into the history of Chemistry, historical civilizations used technology that became the basis of modern-day Chemistry. Chemistry was then treated as par with Alchemy. Though Alchemy and Chemistry have various common aspects in the way they treat matters, Chemistry involves the use of scientific methods to boost the understanding of matter. This fact has been stated by *Robert Boyle* in his book titled *The Sceptical Chymist* published in 1661. This book formed the basis for differentiating Chemistry from Alchemy. Chemistry became an established science after Antoine Lavoisier established that understanding chemical phenomena required careful investigation. The works of Willard Gibbs created a correlation between Chemistry and Thermodynamics [7]. With the addition of new theories and discoveries being made, the definition of Chemistry has changed over time. New disciplines and sub-disciplines are being added that add to the complexity of the subject and have made Chemistry a subject of scientific study.

3. h-Index (Hirsch Index)

Determining the quality of researchers has always been a topic discussed and debated in academic circles. Jorge E. Hirsch, a physicist affiliated with the University of California, San Diego Campus suggested the use of an index that would determine the quality of theoretical physicists in 2005 [8]. Since then, this index has been used in other sciences as well. Hirsch index or h-index is the maximum value of *h* such that the *h* papers published by any author have been cited *h* times [9]. This index is an improvement of previous indices that used the number of publications or the number of citations to assess the productivity of the researcher. The h-index is best used to compare between researchers within the same field [10]. It is one of the several author-level metrics used to assess the impact of the publications and productivity of any researcher. This index has been used for a long time to secure academic fellowships and has also been associated with the prestigious Nobel Prize [11].

Mathematically, if *f* represents the number of citations, and *i* represent the number of the publication,

$$\text{h-index, } f = max\{i \in N: f(i) \geq i\}$$

The h-index has replaced the journal impact factor in categorizing researchers based upon their works. This index considers the most cited works of any researcher and is hence easier to compute and can assume values that equal the number of publications [12].

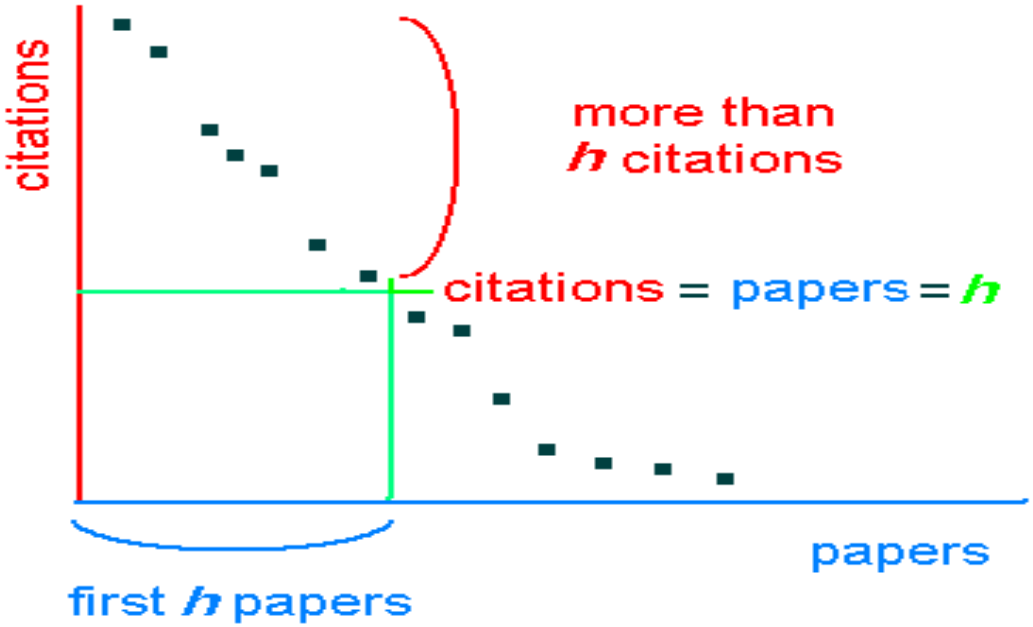


Fig 1: Graph showing h-index (Alonso et al, 2009)

4. Previous Studies on the Concept

There exists a body of evidence suggesting that the h-index is a better choice in evaluating the scholarly work of researchers compared to Impact Factor or Cites Per Paper (CPP) [13, 14, 15]. While the h-index bears correlation with metrics like Impact Factor and Cites Per Paper, these papers are also peer-reviewed in databases like Scopus. The h-index, besides considering the number of citations received by individual scholarly papers, also considers the contribution of the journal in terms of the number of scholarly works published in it. Most of the scientific works do not receive any citations in the first few years of their publication. Impact Factor reviews the impact over the previous two years making it suitable for assessing the scholars. The h-index, on the other hand, measures citations for a longer time making this method more suitable for making assessments. The h-index considers the top *h* papers to calculate the index and does not require the accuracy of data. Further, the lack of sensitivity of h-index to highly cited papers makes it robust and easily comprehensible [16].

This study has used citation from Scopus database to calculate the h-index o Nobel Laureates in Chemistry. Several authors use citations from Google Scholar and Web of Science to calculate the h-index. We have preferred Scopus

over Web of Science and Google Scholar because of the popularity of Scopus over the other databases. Table 1 shows the popularity of Scopus over Google Scholar and Web of Science.

Table 1: Unique and Overlapping Citations in WoS and Scopus

Study	**Three options for citation tracking: Google Scholar, Scopus, & Web of Science [17]**		**A citation analysis of Serbian Dental Journal using Web of Science, Scopus, & Google Scholar [18]**	**A comparison of citation coverage of traditional & web citation databases in medical science [19]**
Sample	50 Journals in JCR Oncology	50 Journals in JCR Physics	158 Articles in Serbian Dental Journals15	2082 Articles in General & Internal Medicine
Citations	614	296	249	62900
Only WoS (%)	7	20	4	10
Only Scopus (%)	18	8	6	11
WoS and Scopus (%)	28	22	15	8
GS and Scopus (%)	5	3	2	9
Total Citations in WoS (%)	70	72	34	51
Total Citations in Scopus (%)	76	54	39	59
Scopus Citations in GS (%)	47	44	48	68

Regarding the source of data, we agree with Martín [20] as they also observed that Scopus is better than WoS. The collection of scientific papers in WoS is lesser than Scopus. Also, WoS mostly covers scientific papers in journals and conferences leaving other sources. Several authors have profiled the achievements of different Nobel Laureates. In a study to create the profile of 47 Nobel Laureates in various fields and 30,000 other scientists [21] authors used various indicators such as h-index, hm-index, CPP, extracted from Scopus. The authors combined all the indices to create a new index *c* and had observed that *c* is highly correlated with *h*. Their results showed that while 31 Nobel Laureates were among the top 14,150 scientists as per the c-index, 18 Nobel Laureates were among the top 14,150 scientists as per the h-index leading them to conclude that the h-index is among the best at creating a profile. Pakkan and his colleagues [22] had conducted a qualitative-quantitative analysis aimed at explaining the importance of the various evaluation metrics using data from the top-ranked institutions in India and observed that the number of cited and un-cited publications has a direct correlation when calculating the quality of the institution. Besides the nature of the publications, the number of publications with collaboration also plays an important part in deciding the rank of institutions. The study observed that the top-ranked institutions have more publications with international collaboration than national collaboration. The authors have observed that the impact of international collaboration is more than that of national collaboration. The study noted that efforts should be made to decrease institutional collaboration while trying to increase international

collaboration as this endeavor increases the visibility of the publications. Abhay Maurya [23] analyzed the bibliometric data of Nobel Laureate George Pearson Smith who started his productive life in 1971. The author has 55 papers to his credit and has a collaboration coefficient of 1.45. The majority of the papers produced by Smith have been published in peer-reviewed journals having a high impact factor. George Pearson Smith has an h-index of 29 primarily due to the low number of papers. Mondal and his colleagues [24] used data of publication outputs from six institutes attached to the department of biotechnology including 6076 journals present in Scopus to conduct a Scientometric study aimed at examining the various Scientometric metrics. The authors observed that the number of scientific publications from the six institutes has increased during the period 1996 till 2019. Although a large number of good articles have been produced, the institutes of biotechnology fail to find a place among the list of prolific institutes in India. The study noted that the failure to find a place among the top institutes in the country was primarily due to the lesser number of publication productivity with international collaboration. The study observed an increase in the number of publications with domestic collaboration. While the institutes of biotechnology in the United States were the main collaborator, the study recommended more international collaboration.

5. Objectives and Methodology

The objective of this study lies in creating the profile of Nobel Laureates in Chemistry using the Hirsch Index calculated using Scopus data and having an understanding of the factors that lead to variation in the h-index. We also look into the validity of the definition of the h-index regarding what is a good value of the h-index. We have created the profiles of Nobel Laureates in Chemistry between 1901 and 2021. These scientists were born between 1835 and 1962, and 41.6% of the Nobel Laureates are still alive and have a median age of 74.5 years. 37 of them have published scientific papers during 2017 and later. Data for the study has been sourced from the Scopus database. Though the profile of Chemistry Nobel Laureates from 1901 till 2021 has been made, many researchers who had been awarded the Prize till 2021 are still active and have exemplary achievements. Alan Jay Heeger, for example, had received the Nobel Prize in 2000 has an h-index of 72 in 2020.

The modus operandi of the entire procedure has been outlined as under:

(i) Data relating to the Chemistry Nobel Laureates from 1901 till 2021 have been downloaded from the Scopus database (https://www.scopus.com / search /form.uri ?display = authorLookup) and selecting the ‘Author’ radio button.

(ii) Three search fields appeared on the page: ‘Author last name’, ‘Author first name’, and ‘Affiliation’. In the first search field, the last name of the author has been entered, and in the second search field, the first name of

the author has been entered. The search field 'Affiliation' has been subsequently verified.

(iii) In the data files of the documents that had appeared, I had selected all the files that contained all variants of the names of the Nobel Laureates as one of the authors of the documents. Only those documents were selected where the name of the affiliating institute matched the institute at the time of receiving the Nobel Prize.

(iv) All selected data were then downloaded in Comma Separated Values (CSV) format.

(v) The data in the CSV file was used to compute the h-index of the Nobel Laureates and this was compared with the figure appearing in the Scopus database.

A total no. of 188 researchers has been conferred with the prestigious Nobel Prize from 1901 till 2021 [25].

6. Analysis and Interpretation

Since the inception of the Nobel Prizes, Nobel Prize in Chemistry has been conferred 111 times to 194 researchers. The only researcher who has won the Nobel Prize in Chemistry twice was Frederick Sanger who was awarded Prize in 1958 and 1980. These Prizes have been conferred to them for outstanding works in various sub-disciplines of Chemistry. As per the covenants of the will left behind by Alfred Nobel, the Nobel Prize can be shared by a maximum of 3 researchers. The subsequent paragraphs analyze the authors on a five-yearly basis.

(i) 1901 till 1905: 5 researchers have been awarded the Nobel Prize in Chemistry from 1901 till 1905. They include Jacobus Henricus van't Hoff (h-index=1), Hermann Emil Fischer (h-index=30), Svante August Arrhenius (h-index=4), Sir William Ramsay (h-index=7), and Johann Friedrich Wilhelm Adolf von Baeyer (h-index=6). The data shows that while Hermann Emil Fischer has the highest h-index, Jacobus Henricus van't Hoff has the lowest h-index, which can be correlated with the number of publications to their credit.

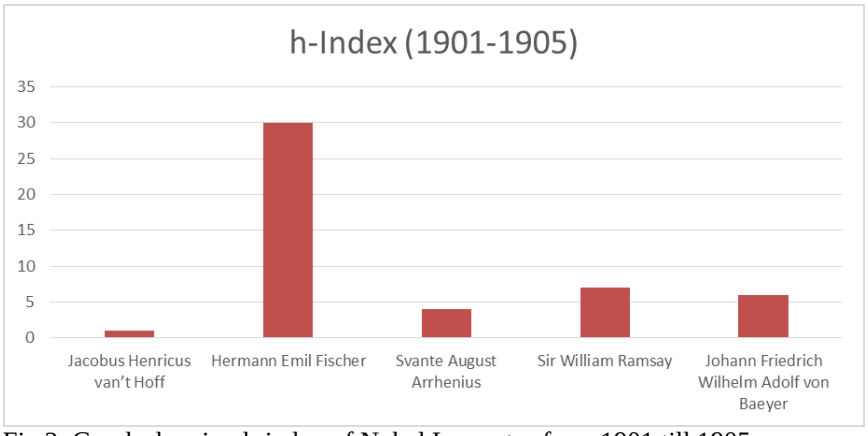


Fig 2: Graph showing h-index of Nobel Laureates from 1901 till 1905

(ii) 1906 till 1910: A graphical representation of the h-index of the Nobel Laureates from 1906 till 1910 is produced in Table 2, which indicates that Otto Wallach has the highest h-index while the lowest h-index pertains to Henri Moissan and Wilhelm Ostwald.

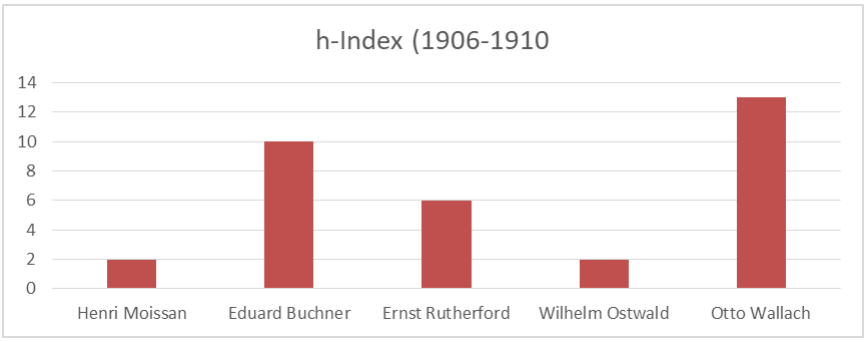


Fig 3: Graph showing h-index of Nobel Laureates from 1906 till 1910

(iii) 1911 till 1915: Of the 6 researchers who have conferred the Nobel Prize in Chemistry during the five years commencing 1911, Marie Curie has the lowest h-index, while Paul Sabatier has the highest h-index. The result of this analysis can be correlated with the number of publications.

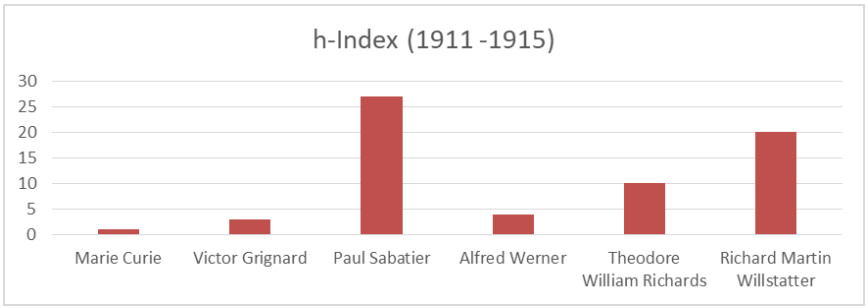


Fig 4: Graph showing h-index of Nobel Laureates from 1911 till 1915

(iv) 1916 till 1920: Nobel Prizes were not awarded during 1916, 1917, and 1919. Between 1918 and 1920, 2 researchers were awarded the Nobel Prize in Chemistry. They are Fritz Haber with an h-index of 10 and Walther Hermann Nernst with an h-index of 9. The graph comparing their h-index is produced in Fig 4.

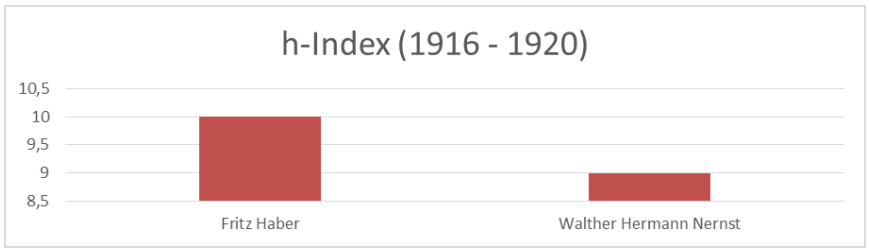


Fig 5: Graph showing h-index of Nobel Laureates from 1916 till 1920

(v) 1921 till 1925: Barring 1924, Nobel Prizes have been awarded every year between 1921 and 1925. The graphical representation shown in Fig 4 indicates that 4 researchers have been conferred the award, among which Fritz Pregl has the lowest h-index while Richard Adolf Zsigmondy has the highest h-index.

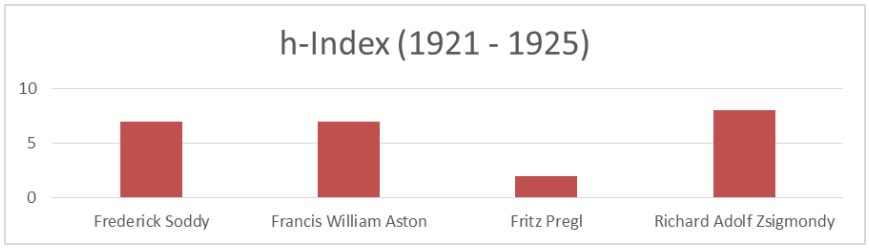


Fig 6: Graph showing h-index of Nobel Laureates from 1921 till 1925

(vi) 1926 till 1930: 6 researchers have been awarded the Nobel Prize in Chemistry during the period 1926 till 1930. An analysis reveals that while Heinrich Otto Wieland has the highest h-index (=18), Arthur Harden has the lowest h-index (=3). Fig 6 is a graphical representation of the information.

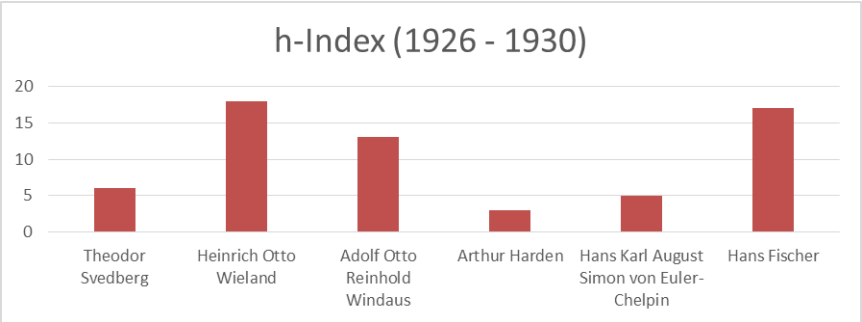


Fig 7: Graph showing h-index of Nobel Laureates from 1926 till 1930

(vii) 1931 till 1935: 2 researchers received the Nobel Prize in Chemistry in 1931 and 1935, while no award was presented in 1933, taking the total tally of Nobel Laureates in Chemistry at 6 during the period under consideration. Fig 7 analyzes the h-index of the researchers, and it is observed that Irving Langmuir has the highest h-index while both Frederick Joliot and Irene Joliot Curie have the lowest h-index. A deep insight into these figures shows that the h-index has a direct correlation with the number of publications.

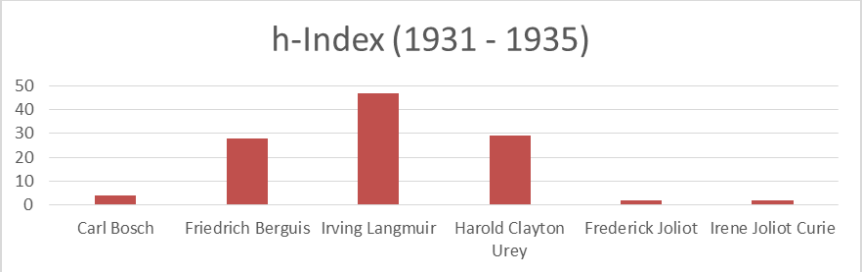


Fig 8: Graph showing h-index of Nobel Laureates from 1931 till 1935

(viii) 1936 till 1940: The Nobel Prizes have not been awarded in 1940. 2 researchers have received the award in 1937 and 1939. 6 researchers have been awarded the Nobel Prize from 1936 till 1940. Analysis of the data shows that Richard Kuhn has the highest h-index, while the h-index

of Petrus Josephus Wilhemus Debye has been calculated to be the lowest. However, all researchers have an h-index above 10.

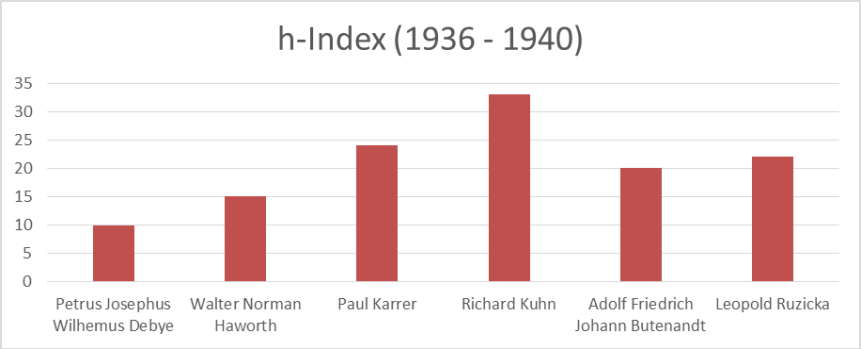


Fig 9: Graph showing h-index of Nobel Laureates from 1936 till 1940

(ix) 1941 till 1945: The Second World War resulted in the Nobel Prize not being awarded during 1941 and 1942. The last three years saw 3 Nobel Laureates in Chemistry. Analysis of the h-index shows that, though the researchers have an h-index of more than 10, the h-index of Arturi Ilmari Virtanen is the highest, while that of Otto Hahn is the lowest.

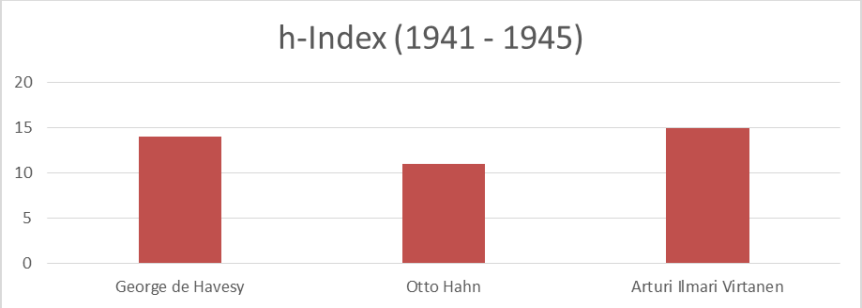


Fig 10: Graph showing h-index of Nobel Laureates from 1941 till 1945

(x) 1946 till 1950: 8 researchers were awarded the Nobel Prize in Chemistry from 1946 till 1950. Analysis of the data shows that Wendell Meredith Stanley had the highest h-index while William Francis Giauque has the lowest h-index. Barring Giauque, all the researchers have an h-index of more than 10.

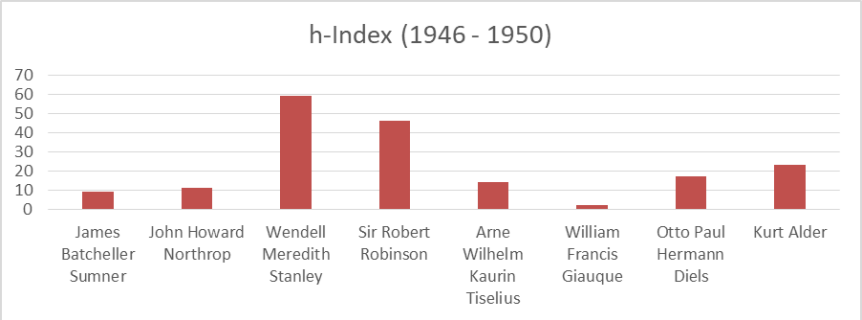


Fig 11: Graph showing h-index of Nobel Laureates from 1946 till 1950

(xi) 1951 till 1955: Of the 7 researchers who had been conferred the Nobel Prize in Chemistry from 1951 till 1955, Linus Carl Pauling has the highest h-index of 69, while Archer John Porter Martin has the lowest h-index of 8. Almost all the researchers have an h-index of more than 10, primarily due to the difference in the number of publications during their lifetime.

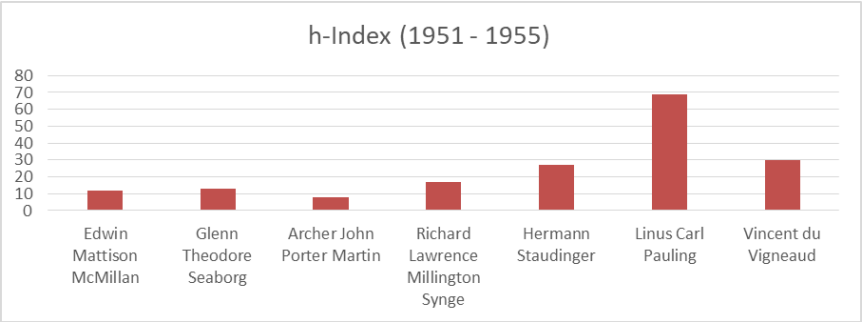


Fig 12: Graph showing h-index of Nobel Laureates from 1951 till 1955

(xii) 1956 till 1960: Of the 6 researchers who had been conferred the Nobel Prize in Chemistry from 1956 till 1960, Frederick Sanger has the highest h-index of 43, while Jaroslav Heyrovsky has the lowest h-index of 7.

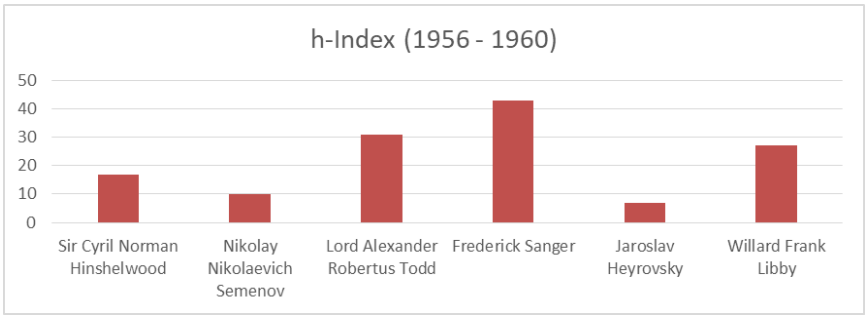


Fig 13: Graph showing h-index of Nobel Laureates from 1956 till 1960

(xiii) 1961 till 1965: 7 researchers were conferred with the Nobel Prize in Chemistry from 1961 till 1965. An analysis of the h-index of these authors reveals that Max Ferdinand Perutz had the highest h-index of 72 while John Cowdrey Kendrew had the lowest h-index of 19. Most of the authors had an h-index of more than 10 indicating high citations and productivity.

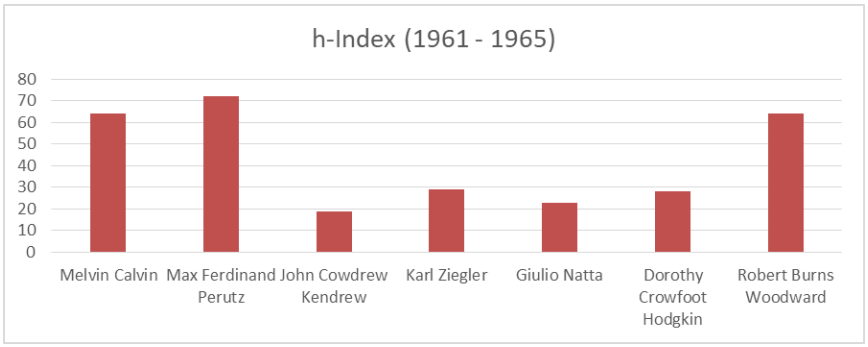


Fig 14: Graph showing h-index of Nobel Laureates from 1961 till 1965

(xiv) 1966 till 1970: The Nobel Committee presented the Nobel Prize in Chemistry to 8 researchers from 1966 till 1970. Of the 8 researchers, Derek Harold Richard Barton, by his higher productivity and higher citations has the highest h-index of 72, while Ronald George Wreyford Norrish has the lowest h-index of 17. However, the h-index of all researchers has been calculated at values higher than 15.

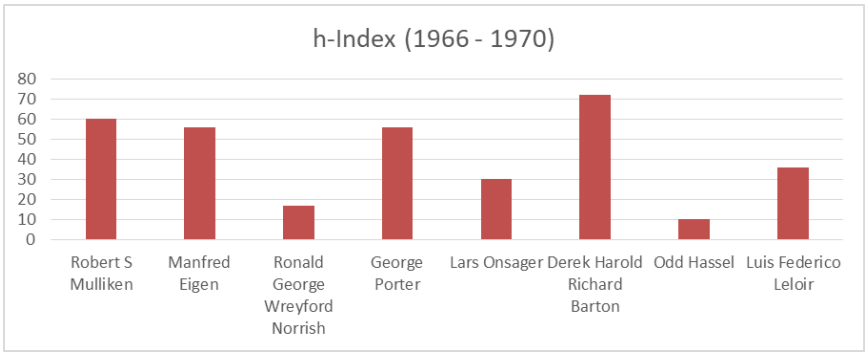


Fig 15: Graph showing h-index of Nobel Laureates from 1966 till 1970

(xv) 1971 till 1975: Of the 9 researchers who had been awarded the Nobel Prize in Chemistry from 1971 till 1975, Paul John Flory who was awarded the Nobel Prize in 1974 had the highest h-index at 104, while the 1975 awardee, John Warcup Cornforth had the lowest h-index of 35.

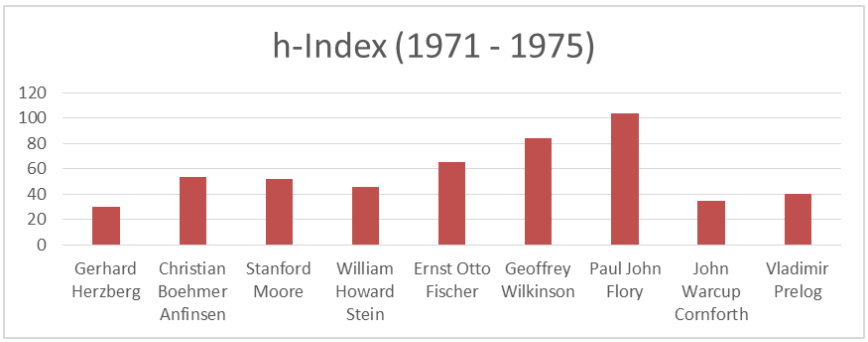


Fig 16: Graph showing h-index of Nobel Laureates from 1971 till 1975

(xvi) 1976 till 1980: Analysis of the h-index of the 8 researchers who were awarded the Nobel Prize in Chemistry in the years 1976 till 1980, Frederick Sanger had the lowest h-index at 43, while the h-index of Herbert Charles Brown has been calculated at 103 which is the highest.

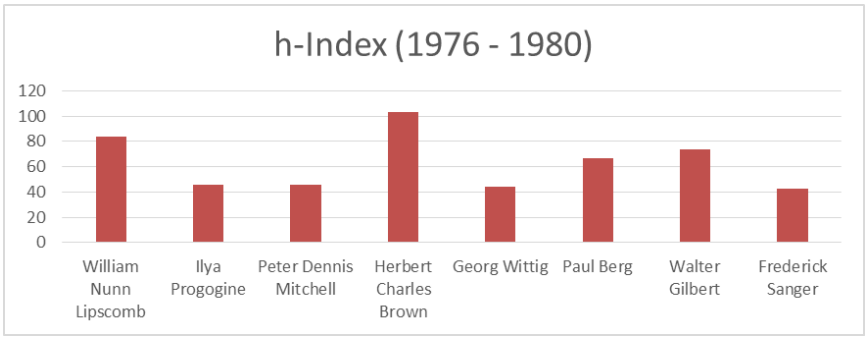


Fig 17: Graph showing h-index of Nobel Laureates from 1976 till 1980

(xvii) 1981 till 1985: Analysis of the h-index of the 7 Nobel Laureates in Chemistry from 1981 till 1985 shows that Roald Hoffman has the lowest h-index of 1, while the h-index of Aaron King has been calculated at 84. Barring Hoffman, all Nobel Laureates have an h-index of more than 15.

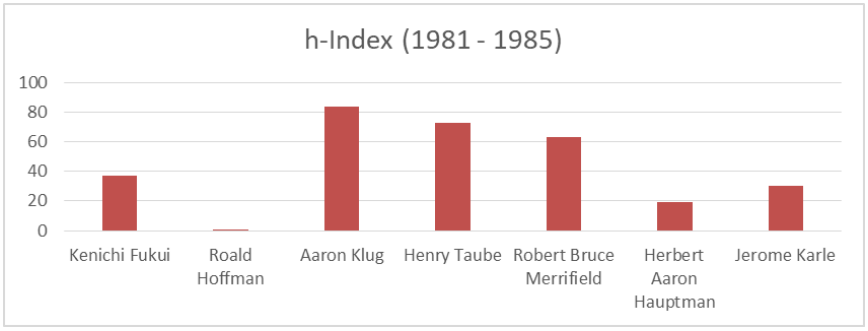


Fig 18: Graph showing h-index of Nobel Laureates from 1981 till 1985

(xviii) 1985 till 1990: The years from 1985 till 1990 witnessed 12 researchers being awarded the Nobel Prize in Chemistry. Upon analysis of the h-index, the correlation between the number of publications and the h-index has been observed. The higher number of publications results in a higher value of the h-index. During the years under review, Elias James Curie has the highest h-index of 147, while the lowest h-index has been calculated for Charles John Pedersen at 15.

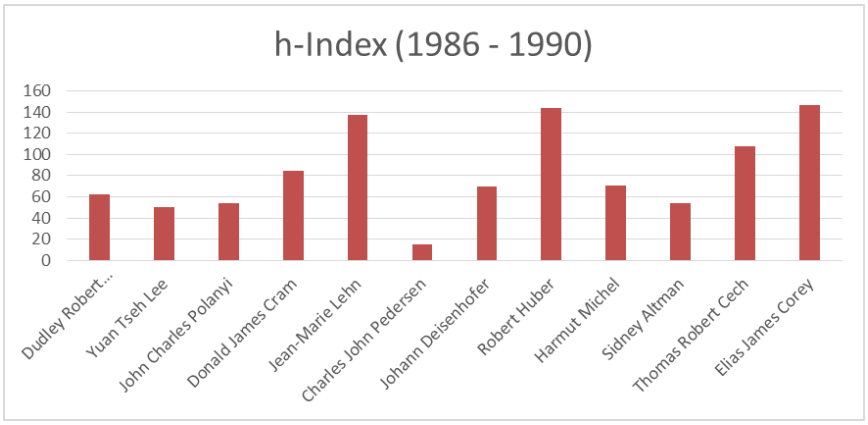


Fig 19: Graph showing h-index of Nobel Laureates from 1989 till 1990

(xix) 1991 till 1995: 8 researchers were awarded the Nobel Prize in Chemistry during the 5 years commencing 1991. The lowest h-index has been calculated at 11 while the highest h-index has been calculated at 110. Mario Jose Molina Pasquel Henrique holds the distinction of having the lowest value of the h-index while Paul Jozef Crutzen has the highest value of the h-index. A graphical representation of the analysis is provided in Fig 18 below.

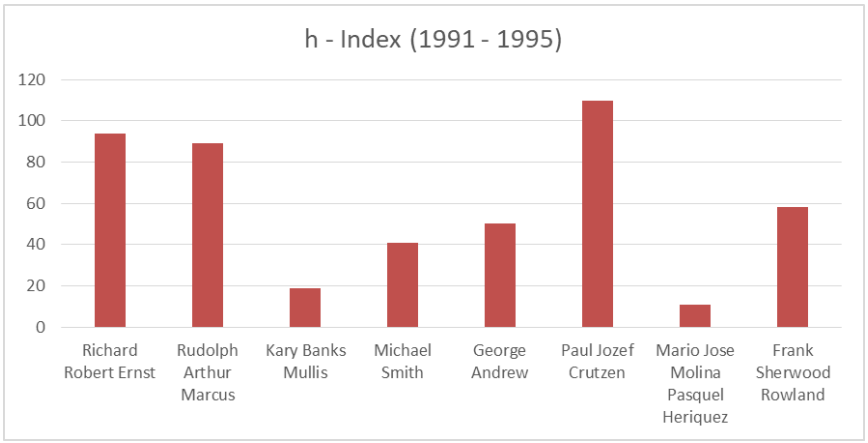


Fig 20: Graph showing h-index of Nobel Laureates from 1991 till 1995

(xx) 1996 till 2000: The Nobel Committee awarded the Nobel Prize in Chemistry to 12 researchers during the period 1996 till 2000. The h-index of the researcher is145.

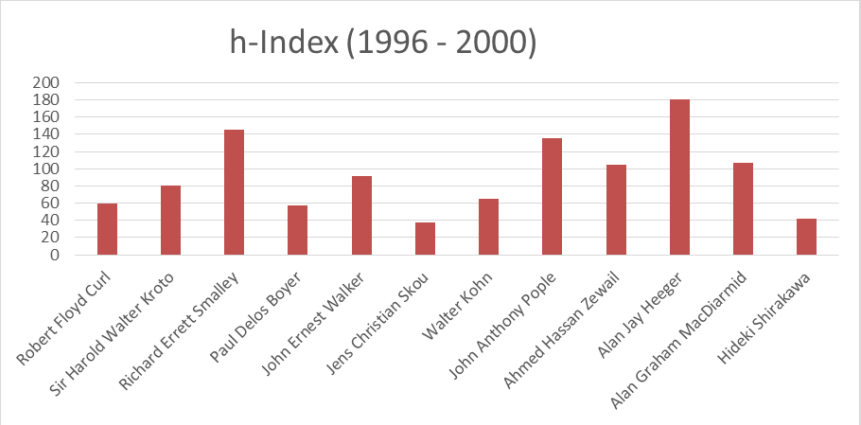


Fig 21: Graph showing h-index of Nobel Laureates from 1996 till 2000

(xxi) 2001 till 2005: 14 researchers were conferred with the Nobel Prize in Chemistry from 2001 till 2005. An analysis of the h-index of these authors reveals that William Standish Knowles had the lowest h-index of 12 while Kurt Wuthrich had the highest h-index of 139. Most of the authors had an h-index of more than 50, suggesting that their works have been cited by succeeding authors.

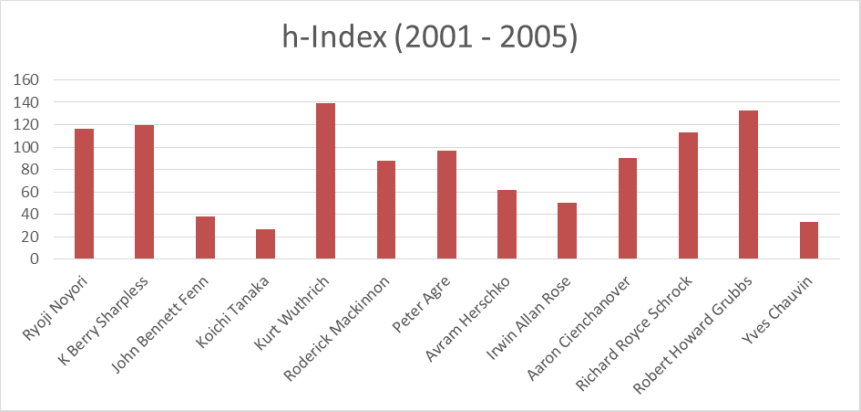


Fig 22: Graph showing h-index of Nobel Laureates from 2001 till 2005

(xxii) 2006 till 2010: The 5 years post-2006 saw 11 researchers being conferred the Nobel Prize in Chemistry with Ada Etil Yonath having the lowest h-index of 43. The figures show that the scholarly works of the researchers have been cited by the younger generation of researchers, showing their popularity.

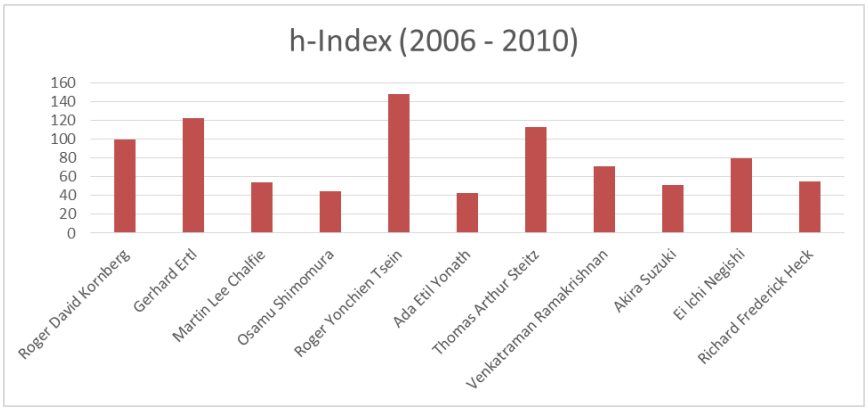


Fig 23: Graph showing h-index of Nobel Laureates from 2006 till 2010

(xxiii) 2011 till 2015: During the years 2011 till 2015, 12 new researchers were given the Nobel Prize in Chemistry. All of the Nobel Laureates had an h-index above 60, baring Daniel Shechtman who had an h-index of 29. The observed figures suggest the popularity of their works among junior researchers who have carried their works further.

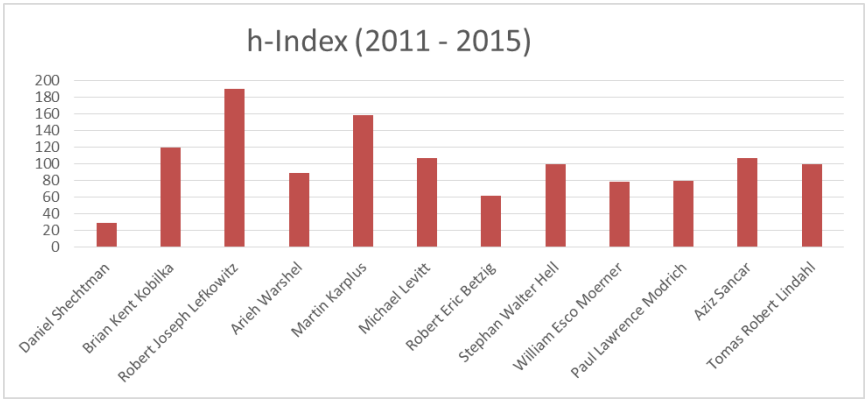


Fig 24: Graph showing h-index of Nobel Laureates from 2011 till 2015

(xxiv) 2016 till 2020: Among the 14 researchers given the Nobel Laureates in Chemistry, Akira Yoshino had an h-index of 12 mainly due to publishing his works in Japanese. Akira Yoshino has been able to induce future generations to conduct further research in Chemistry and his achievement has been commendable.

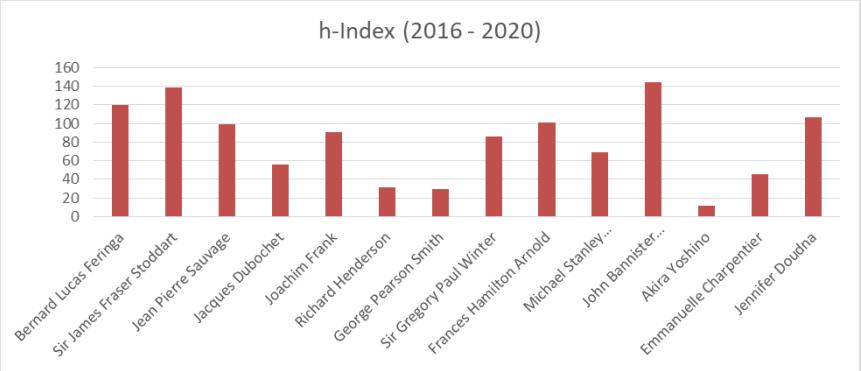


Fig 25: Graph showing h-index of Nobel Laureates from 2016 till 2019

(xxv) 2021: Among the 2 researchers given the Nobel Laureates in Chemistry, David W.C. MacMillan had an h-index of 100.

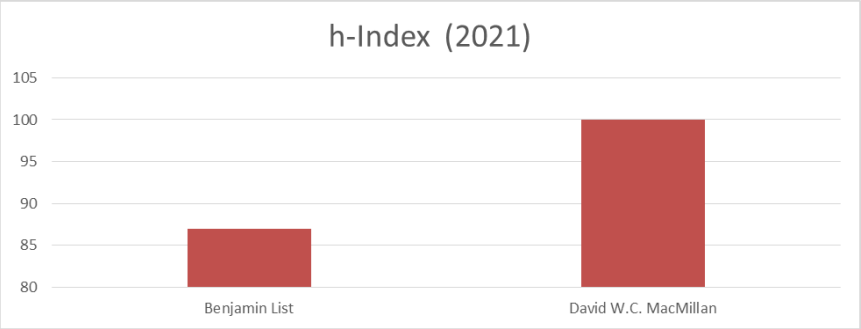


Fig 26: Graph showing h-index of Nobel Laureates in 2021

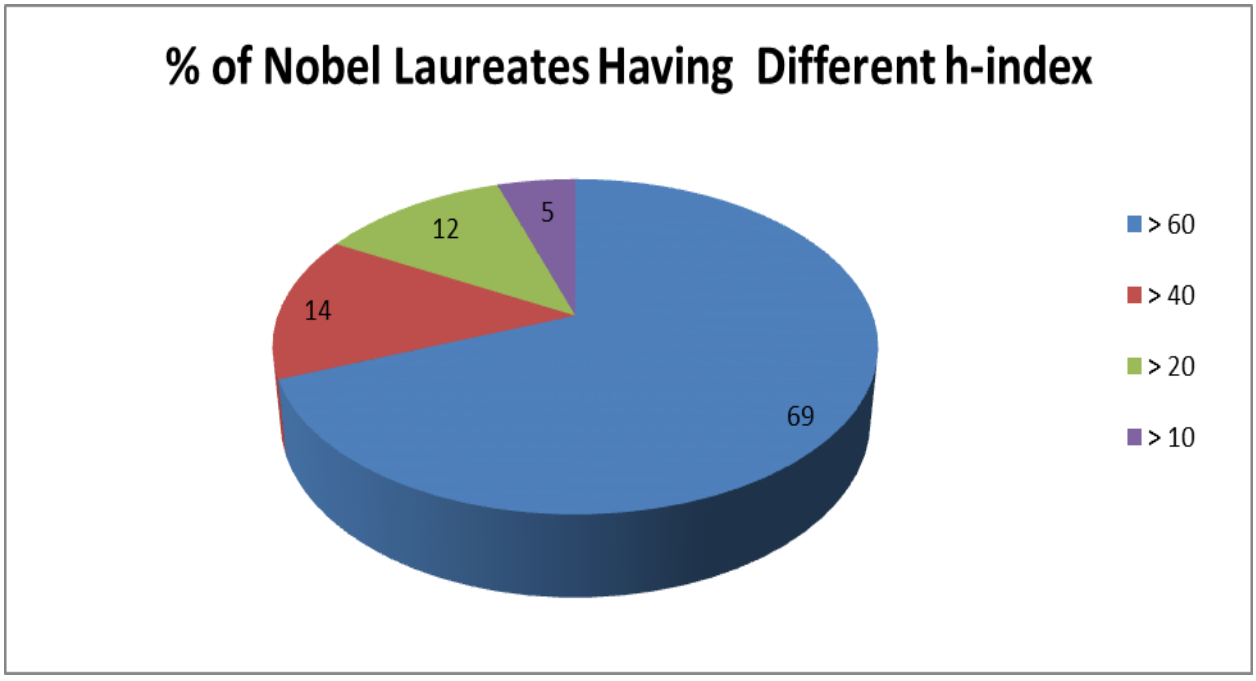
7. Findings and Conclusion

Certain positive aspects of the h-index have prompted us to compare the quality of the output of the researchers who have been awarded the Nobel Prize in Chemistry. Among the aspects is the objectivity of the calculation allowing easy comparison among the Nobel Laureates. H-index rewards excellence over

longer periods, with highly cited papers not getting preferential treatment over the less cited ones. Multi-authored papers receive the same treatment as single-authored ones, and the position of the author does not affect the value of the h-index. With self-citation being considered for the calculation of the h-index, the value of the h-index can never decrease. Certain scholars, however, feel that the h-index does not favor recent achievements. Hirsch believed that an h-index equal to 20 can be considered good, with an h-index of 40 being considered outstanding, while an h-index equal to 60 can be considered exceptional [8]. The h-index is biased towards age and increases with the increase in the number of papers published by the author. Papers published in regional languages fail to be cited internationally leading to the lower value of the h-index. Our findings show that 69% of the Nobel Laureates have an h-index of more than 60, and only 5% have an h-index of less than 10. This shows that the Nobel Laureates enjoy popularity among the younger researchers who have cited their works in future works. Besides having a direct correlation with the number of citations, the h-index also varies according to the number of publications produced by any researcher. A lower number of publications generally yield a lower value of h-index and the same holds good for higher productivity. Our analysis has observed that Hirsch Index correlates with the number of publications and the citations received by those publications. It may be argued that higher productivity is dependent upon the period of productivity of the individual researchers. A total no. of 188 researchers has been awarded the Nobel Prize in Chemistry since the inception of the award in 1901 till 2021. The awards have been given every year baring a few years during the two world wars when the awards were not announced. The data is indicative of the fact that the highest value of the h-index is 181 while the lowest value is 1. Analysis of the values of the h-index has also indicated that the value of the h-index has a direct correlation with the number of scientific productions and the number of citations.

The researchers who have been awarded the Nobel Prize in the early years show a low value of h-index compared to those researchers who have been awarded the same in the latter part. This phenomenon is understandable as scientific productivity had been low during the early period. With the advent of electronic media of publications, and the higher numbers of co-authors, the number of publications has witnessed an increase resulting in higher values of the h-index. Further, the rising popularity of undertaking research has also prompted future researchers to cite the previous works leading to an increase in the number of citations and higher values of the h-index. Our analysis has observed that in case more than 1 researcher has been awarded the Nobel Prize during any particular year, the value of the h-index is nearly similar to the values of the h-index of the other researchers who have been awarded the prize during that year.

Fig 25: Pie chart showing h-index of Nobel Laureates



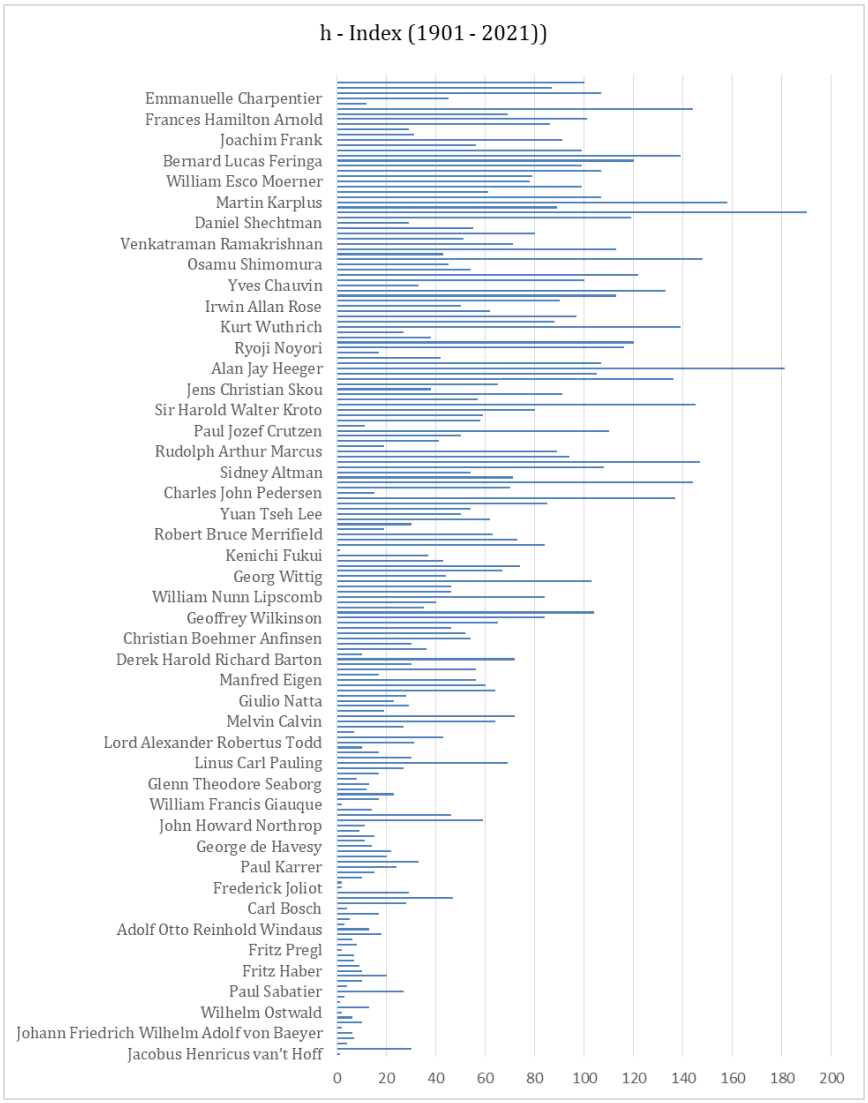


Fig 26**:** Graph showing h-index of Nobel Laureates from 1901 till 2021

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