

Clues to Prolific Productivity among Prominent Scientists

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Abstract—In a survey based on the biographical sketches, obituary notes and eulogies of notable scientists, eight were identified as belonging to an elite group, having authored more than 1000 research publications, which include books, monographs and patents. They were, in chronological order, Thomas Alva Edison, Paul Karrer, Margaret Mead, Giulio Natta, Hans Selye, Herbert C Brown, Tetsuji Kametani and Carl Djerassi. Among these, Karrer, Natta and Brown were Nobelists in chemistry. Four criteria which can be identified as clues to their prolific productivity are, 1) enthusiasm for compulsive work and eccentric life style, 2) physical and/or environmental handicap, 3) pioneering efforts in a new research field, and 4) selection of research area, predominantly organic chemistry.

Introduction

On an average, a productive career among scientists spanning 4 decades can result in the generation of approximately 120 to 160 research publications. This is based on a calculation of a reliable rate of 3 to 4 publications per annum. However, some notable scientists have published more than 1000 research publications (which include books, monographs and patents) during their highly productive careers. In the absence of an identifying tag for these scientists, I wish to refer to them as 'Kilo-Base Goliaths (KBGs)'. Compared to the productivity of a successful average scientist, the productivity of KBGs has been ten fold higher. What factors can contribute to this prolific productivity?

To the best of my knowledge, only a couple of reports (1, 2) have been published which comment briefly on the productivity of the KBGs. Even

the *Guinness Book of Records* (3) which provides quantitative information on matters related to human achievement and endurance does not provide any details about the KBGs. Previously, Garfield (1) has identified two KBGs, though without proper documentation. American entomologist Theodore Dru Alison Cockerell and Soviet crystallographer Nikolai Vassilovich Belov are credited as having 3904 and 1500 publications respectively.

The objective of this report is to summarise scattered information on the KBGs and identify the criteria which would have contributed to their prolific productivity.

Materials

From the scientific journals, abstracting sources like the *Chemical Abstracts* and reference sources such as

the *Encyclopedia Britannica*, biographical sketches, obituary notes and eulogies were scanned for the number of publications relating to prominent scientists. Eight scientists were identified as belonging to the elite group of intellectuals who have authored more than 1000 research publications, which include books, monographs and patents.

Results and discussion

Table 1 provides details about the 8 scientists who demonstrated prolific productivity. Among these, 2 (Edison and Mead) were American-born scientists; 3 (Selye, Brown and Djerassi) were European emigres who settled in the USA or Canada; 2 (Karrer and Natta) were Europeans and 1 (Kametani) was a Japanese. Of these 8 KBGs, 2 are still living in 1992. Herbert Brown is 80 years old and Carl Djerassi reached 69 years. The other 6 lived for more than 70 years. There means (\pm SD) life span was 77.5 ± 4.8 years. Edison and Karrer lived for 84 and 82 years respectively. If one assumes that their first research contribution appeared when they were around 25 years, their productive career would have spanned 5 decades. If this is so, to accumulate 1000 research publications, they would have averaged approximately 20 publications per year for 5 decades.

For example, Edison filed his first patent in 1868, at the age of 21, for a telegraphic vote-recording machine. At the age of 25, he took out 38 patents and in the subsequent year, he was granted 25 patents.

Biographical details of the KBGs and aspects related to the social history and developmental stages of science during their lifetime suggest the following four criteria as playing significant roles in their prolific productivity.

1. Enthusiasm for compulsive work and eccentric life style

An enthusiasm for compulsive work seems a common thread which links the work pattern of most, if not all, KBGs. Indulgence in hard labour by Edison (15), Selye (19, 20) and Djerassi (21) has been recorded by their biographers and junior associates. Djerassi, for example, summed up his enthusiasm for compulsive work as; 'I think I was always operating at 98% efficiency; so there was only 2% left for other things, for my personal life' (21). This jet-pace did affect Djerassi's personal life in that he was twice-divorced and his daughter committed suicide.

Eccentricity also characterises the lifestyles of these KBGs. Edison was an uninhibited egotist and

Table 1 Prolific productivity among scientists; An analysis of 'Kilo-base Goliaths' (KBGs)

Scientists with years of birth & death	Productivity unit	Area of speciality	Reference
Hans Selye 1907-1982	1700 papers, 15 monographs and 7 popular books	endocrinology	4, 5
Margaret Mead 1901-1978	1397 papers, 39 books and 43 records and tapes	anthropology	6, 7
Tetsuji Kametani 1917-1988	1201 papers	organic chemistry	2, 8, 9
Giulio Natta* 1903-1979	1200 papers	organic chemistry	10, 11
Carl Djerassi 1923-	1150 papers & 8 books	organic chemistry	1, 2, 12
Herbert C Brown* 1912-	1112 papers & 3 books	organic chemistry	13, 14
Thomas A. Edison 1847-1931	1093 patents	invention & design	15, 16
Paul Karrer* 1889-1971	> 1000 papers, 2 books and a monograph	organic chemistry	17, 18

* Nobelists in Chemistry

he slept for only 3 or 4 hours in the night. The regular 8 hour sleep was a waste of precious time according to Edison and he believed that it was a remnant of a cave-living heritage. To compensate for the reduction of night sleep, he was able to 'catnap' at any time. Karrer refused to own an automobile and upon his retirement from active work in 1959, he burned most of his scientific correspondence. Selye 'worked every day', and 'lived in the laboratory, doing surgery himself, handling animals, looking at histological slides and writing profusely' (19, 20).

For an American woman, born in Bucks County, Pennsylvania, in 1901, Margaret Mead also led an unconventional life. She married three times between 1923 and 1935. She also made more than 20 field trips to distant places such as the Samoan Islands, Admiralty Islands, New Guinea and Bali Islands between 1925 and 1975. The obituary note in *Nature* (6) records that her 'bibliography runs to nearly 4,000 items'. Apart from the 1397 papers and 39 books cited by her biographer (7), I presume the balance constitutes the popular writings of Margaret Mead. Regarding Mead's work habits, one of her colleagues had noted: 'She (Mead) was annoyed with banalities. She never went through lengthy greetings or goodbyes on the telephone. When the point was made, the line went dead' (22).

2. Physical and/or environmental handicap

Poverty in childhood and disruption of education by physical handicap or environmental insult (such as the Great Depression of the early 1930s or the Nazi holocaust) characterize the lives of Edison (15), Brown (23) and Djerassi (1, 24). Edison suffered permanent hearing loss after a bout of scarlet fever and was plagued by halitosis as well (25). Furthermore, he was expelled from grade school as a retarded child and was educated at home by his mother. It has been claimed that Edison's deafness enabled him to concentrate on the telegraph's clicks which resulted in his invention of wireless telegraphy. Natta developed the symptoms of Parkinson's disease at the age of 53 years, though he continued his research work for an additional 17 years and retired only after reaching 70 years (10).

3. Pioneering efforts in a new field of research

Table 2 shows the significant contributions of the 8 KBGs investigated. It becomes evident that these scientists explored virgin areas of research and they faced relatively few competitors when they ploughed

these untouched fields. For their pioneering contributions, Karrer, Natta and Brown were awarded the Nobel prize in chemistry. There is no doubt that others such as Edison, Selye, Kametani and Djerassi are in the highest category among the natural scientists. Anthropologist Margaret Mead also hoped for the Nobel peace prize during her life time (7), though she was not awarded one.

4. Selection of research subject

Of the 8 KBGs, 5 produced their publications in the field of organic chemistry. This suggests that producing a publication in organic chemistry may be relatively quicker, than in areas such as bio-medical sciences and physical sciences. However, Hans Selye seems to be an exception in that he conducted research in the areas of endocrinology and clinical medicine.

Among the 8 KBGs, the complete list of Kametani's 1201 publications has been published recently (9). A statistical analysis of Kametani's publications shows that he published his first paper in 1945 (26). There was a 4 year gap (1946-49) before his second publication in 1950. This could be attributed to the hard times in Japan after the Second World War, when Kametani was just beginning his professional career. He reached his 100th publication in 1963; 200th in 1967; 300th in 1968; 400th in 1970; 500th in 1972; 600th in 1974; 700th in 1976; 800th in 1979; 900th in 1981 and 1000th in 1983. Between 1967 and 1982, he averaged 35 or more publications per year, reaching the peak of 76 publications in 1971. What is remarkable about Kametani's 1000 publications is the fact that, his is the 'longest run of chemistry papers on a single theme—'Studies on the syntheses of heterocyclic compounds and natural products' (2).

Compared to Kametani, Brown published his first paper in 1939 (27) and his 1000th paper in 1986 (13). The maximum number of publications Brown had in any year was 46 and this also coincidentally occurred in 1986. The most productive year, *annus mirabilis*, for Brown was 1942, in which he 'discovered a) the molecular addition compound approach to steric effects; b) alkali metal hydride route to diborane; c) sodium borohydride and its value as a reducing agent in organic chemistry' (14). Djerassi's first paper appeared in 1946 (28) and his 1000th paper came in 1981 (2).

Two other prominent scientists have demonstrated prolific productivity, though yet to become KBGs. Chemist Linus Pauling (born in Portland, USA, in 1901) is still active in research and according to recent counts has published over 700 scientific papers,

Table 2 Pionering contributions by the 'Kilo-base Goliaths'

<i>Scientists</i>	<i>Pioneering contributions</i>
Hans Selye	Stress concept of health and disease; steroids and inflammation
Margaret Mead	Ethnographic studies of Pacific cultures; Investigations on problems of childbearing, adolescence, sex roles and personality
Tetsuji Kametani	Development of new pharmacologically active heterocyclic compounds; establishment of new routes for the industrial preparation of medicines
Giulio Natta	Theory and technology of stereospecific polymerization; concept of 'tacticity'
Carl Djerassi	Mass spectrometry in structural and stereochemical problems; optical rotatory dispersion studies; terpenoids and alkaloids; synthesis of first oral contraceptive
Herbert C. Brown	Discoveries related to organoboranes and exploitation of their innumerable reactions; establishment of the structures of the carbonium ions
Thomas Edison	Inventions related to 20th century life; fundamental concepts of telephone, wireless telegraphy, electric light, phonograph, motion picture projector, electric vote recorder
Paul Karrer	Elucidation of the structure of carotenoids; Research on other vitamins such as ascorbic acid, tocopherol and flavins

about 200 articles on social and political issues and about 12 books (29, 30, 31). He received the unshared 1954 Nobel prize for chemistry and 1962 Nobel prize for peace. Pauling published his first research paper in 1923 (32) and has continued to publish regularly till now. This 69-year publishing record shows an endurance which only a few intellectuals can boast of. Noted endocrinologist Andrew Schally (born in Wilno, Poland in 1926) has 815 research publications to his credit, according to the National Library of Medicine computer data base which covers the period from 1965. He received the 1977 Nobel prize for medicine or physiology for his pioneering discovery and synthesis of hypothalamic hormones.

Finally, the prolific productivity of mathematical logician, philosopher and prominent social activist Bertrand Russell (1872–1970) also deserves mention. Since his first book, *German Social Democracy* (1896), after receiving a first-class degree in moral sciences in 1894, Russell's bibliography after 75 years of prolific writing exceeds over 2000 publications (33). These include more than 75 books and pamphlets ranging in topics from philosophy, mathematics, science and ethics to sociology, education, history, religion and politics. Russell's reputation as a mathematical logician rests with his works, *The Principles of Mathematics* (1903), three volumes of *Principia Mathematica* (1910–13) and *Introduction*

to Mathematical Philosophy (1919). The three volume *Principia Mathematica* was co-authored with his friend, former tutor and mathematician Alfred Whitehead. Russell was also a popularizer of science and authored well-received works such as *The ABC of Atoms* (1923), *The ABC of Relativity* (1925) and *The Impact of Science on Society* (1951). He was awarded the 1950 Nobel prize for literature, perhaps the only mathematician to be recognized in this category. His entry in the *Encyclopedia Britannica* notes that, 'he (Russell) normally wrote at the rate of 3000 largely unaltered words a day' (34).

Conclusion

From a survey of 8 prominent scientists who have published more than 1000 research papers, one can identify four criteria as clues to prolific productivity. These are, 1) enthusiasm for compulsive work and eccentric life style, 2) physical and/or environmental handicap, 3) pioneering efforts in a new research field, and 4) selection of research subject, predominantly organic chemistry.

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