

## Acknowledgements in Francis Crick's papers appearing in science journals

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*Apart from citation counting, the study of recorded acknowledgements by researchers as a recognizable metric to evaluate peer influence is currently gaining momentum. As a metric, acknowledgements have an advantage over citations. Whereas citations can be copied and pasted from one publication to the next by an unscrupulous researcher without being studied in depth, acknowledgements cannot be lifted in such a duplicitous style. Here I present an exploratory survey of acknowledgement patterns in journal papers by Francis Crick. Five principal categories (namely, moral, financial, editorial, instrumental/technical and conceptual) were studied from 104 papers authored by Crick, either solely or collaboratively, over a span of five decades. To the best of my knowledge, there are no earlier studies where acknowledgement patterns of a well-recognized interdisciplinary scientist are reported cumulatively.*

'Crick scholarship is in its infancy. There is, as yet, no published edition of his scientific papers', wrote Chris Beckett<sup>1</sup> referring to Francis Harry Compton Crick (1916–2004), considered as one of the giants of the 20th century science. Crick is considered as the great provocateur and catalyst for inspiring new disciplines (crystallography, molecular biology, behavioural neuroscience). Two biographies on Crick authored by Ridley<sup>2</sup> and Olby<sup>3</sup> have appeared. Olby<sup>3</sup> had mentioned the dilemmas faced by James Watson and Crick in writing the acknowledgements for their first groundbreaking announcement of the double-helical structure of DNA in 1953. This description inspired me to study what strategies Crick adopted in writing acknowledgements for his other journal papers.

Previously, I have studied the citation patterns on four of the seminal DNA double-helix model papers co-authored by Crick in 1953–54 (ref. 4). Apart from citation counting, the study of recorded acknowledgements by researchers as a recognizable metric to evaluate influence of peers is currently gaining momentum<sup>5–8</sup>. From a Crick bibliography on published journal papers<sup>9</sup> (Table 1), categories of acknowledgements, which ever included, were recorded.

### Commentary

Among the 104 papers of Crick retrieved from databases, a total of 58 acknowledgements were recorded for this study. Acknowledgements were missing in 46 papers. Two among the 104 collected

papers of Crick were published posthumously in 2005 and 2013. Generally, acknowledgement-appearing papers were experimental and original idea papers. Acknowledgement-missing papers were mostly expository articles (in popular science journals like *Scientific American*, *The Sciences* and *New Scientist*), brief commentaries, contributions to the 'letters to the editor' and memoriam items. Table 2 shows authorship composition among the papers by Crick. Single-author category dominates with 50.0%, followed by double-author category with 34.6%. Prominent collaborators who shared authorship with Crick in the double author category include Christof Koch (9 papers), James Watson (5 papers), Leslie Orgel (4 papers), Alex Rich

(3 papers), Beatrice Magdoff (3 papers) and Graeme Mitchison (3 papers). Even among the 9 triple-authored papers only in one paper Crick was placed as the last author.

Crick published his first two papers in 1950. While the first paper<sup>10</sup> in which he was the first author was co-authored with Hughes, Crick was the sole author in his second paper<sup>11</sup>. Both appeared in volume 1 of *Experimental Cell Research*. Table 3 presents acknowledgements which appeared in these two papers, as well as representative samples of 13 acknowledgements<sup>12–24</sup> which had appeared in papers from 1953 to 2003. In these 15 selections, wherever feasible, I have chosen only the papers in which Crick was the sole author. Co-authored papers are

**Table 1.** Papers\* by Francis Crick which had appeared in science journals (1950–2013)

Category	Number (%)
Total number of papers retrieved from databases	104
Posthumously published papers (in 2005 and 2013)	2 out of 104 (1.9)
Acknowledgement-appearing papers	58 out of 104 (56.0)
Acknowledgement-missing papers	46 out of 104 (44.0)

\*Includes multiple varieties: original papers, reviews, hypotheses, concepts, commentaries, letters to the editor, symposium papers, memoriam, revised transcripts of lectures delivered, and popular articles in *Scientific American*, *The Sciences* and *New Scientist*.

**Table 2.** Authorship composition among the papers by Francis Crick

Category	Number (%)
Single-authored	52 (50.0)
Double-authored	36 (34.6)
Triple-authored	9 (8.6)
More than three authors	7 (6.7)
Total	104 (99.9)

**Table 3.** Titles (published years) of representative papers and the acknowledgements reported by Crick

Title of representative papers (Year)	Acknowledgements
The physical properties of cytoplasm. A study by means of the magnetic particle method. Part 1: Experimental (1950)	The authors wish to express their thanks to Dr H. B. Fell for her continued help during the course of the work, to the Medical Research Council for a studentship held by the senior author, and to Mr L. J. King for his skilled preparation of most of the tissue cultures used in this work <sup>10</sup> .
The physical properties of cytoplasm. A study by means of the magnetic particle method. Part II. Theoretical treatment (1950)	The author wishes to thank Dr Honor B. Fell for the hospitality of the Strangeways Research Laboratory, the Medical Research Council for a Studentship, and Mr G. Kreisel for many helpful and characteristic suggestions on presentation <sup>11</sup> .
A structure for Deoxyribose nucleic acid (1953)	We are much indebted to Dr Jerry Donohue for constant advice and criticism, especially on inter-atomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr M. H. F. Wilkins, Dr R. E. Franklin and their co-workers at King's College, London. One of us (J.D.W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis <sup>12</sup> .
The packing of $\alpha$ -helices: simple coiled-coils (1953)	I should like to thank Sir Lawrence Bragg and also my colleagues in the Medical Research Council Unit both for the interest they have shown in this problem and for helpful suggestions and criticisms <sup>13</sup> .
General nature of the genetic code for proteins (1961)	We thank Dr Alice Orgel for certain mutants and for the use of data from her thesis, Dr Leslie Orgel for many useful discussions, and Dr Seymour Benzer for supplying us with certain deletions. We are particularly grateful to Prof. C. F. A. Pantin for allowing us to use a room in the Zoological Museum, Cambridge, in which the bulk of this work was done <sup>14</sup> .
Codon-anticodon pairing: The wobble hypothesis (1966)	I thank my colleagues for many useful discussions and the following for sending me material in advance of publication: Dr M. W. Nirenberg, Dr H. G. Khorana, Dr G. Streisinger, Dr W. Holley, Dr J. Fresco, Dr H. G. Zachau, Dr C. Yanofsky, Dr H. G. Wittmann, Dr W. Lehmann and Dr J. D. Watson <sup>15</sup> .
Diffusion in embryogenesis (1970)	I thank my wife for drawing the figure, my colleagues, especially Dr Peter Lawrence and Mrs Mary Munro, for many helpful discussions, and Professors Lewis Wolpert and W. D. Stein for sending me information <sup>16</sup> .
Linking numbers and nucleosomes (1976)	I wish especially to thank Prof. Fuller, for many useful points made in correspondence and for allowing me to quote unpublished work, and Dr Graeme Mitchison of this laboratory for helpful explanations and discussion, and in particular for the neat proof shown in Figure 3b and c. I also thank Dr. Aaron Klug and Prof. J. Vinograd for valuable comments <sup>17</sup> .
Split genes and RNA splicing (1979)	I thank J. Abelson, G.G. Brownlee, P. Chambon, J. E. Darnell Jr, I. B. Dawid, D. S. Hogness, P. Leder, B. W. O'Malley, P. P. Slonimski, S. Tonegawa, S. M. Weissman and E. B. Ziff for providing me with unpublished material, and J. Abelson, P. Chambon, W. Gilbert, L. E. Orgel and S. Tonegawa for useful comments on the manuscript. This work was supported by the Eugene and Estelle Ferkauf Foundation, J.W. Kieckhefer Foundation, and Samuel Roberts Noble Foundation, Inc. <sup>18</sup> .
The function of dream sleep (1983)	We thank our resident and visiting colleagues at The Salk Institute for many useful discussions. We are especially grateful to Drs Allan Hobson and Jim Horne who made detailed comments on our draft manuscript, and to Dr John Hopfield for communicating his work to us before publication and for helpful discussions. This work has been supported by the J.W. Kieckhefer Foundation, Samuel Roberts Noble Foundation, US Air Force Grant number AFOSR-82-0042 and the System Development Foundation <sup>19</sup> .

(Contd)

## HISTORICAL NOTES

**Table 3.** (Contd)

Title of representative papers (Year)	Acknowledgements
Function of the thalamic reticular complex: The searchlight hypothesis (1984)	This work originated as a result of extensive discussions with Dr Christopher Longuet-Higgins. I thank him and many other colleagues who have commented on the idea, in particular, Drs Richard Anderson, Max Cowan, Simon LeVay, Don MacLeod, Graeme Mitchison, Tomaso Poggio, V. S. Ramachandran, Terrence Sejnowski, and Christoph von der Malsburg. This work has been supported by the J. W. Kieckhefer Foundation and the System Development Foundation <sup>20</sup> .
The recent excitement about neural networks (1989)	Thanks are due to Patricia Churchland, David Rumelhart and Terry Sejnowski for helpful comments. This work was supported by The Kieckhefer Foundation and The System Development Foundation <sup>21</sup> .
REM sleep and neural nets (1995)	We thank our colleagues for many helpful comments, in particular Richard Durbin, Robert Haskell, Allan Hobson, John Hopfield and Liam Hudson. This work was supported by the J. W. Kieckhefer Foundation, the System Development Foundation and the Samuel Roberts Noble Foundation <sup>22</sup> .
The impact of molecular biology on neuroscience (1999)	I have benefited from discussions with Sydney Brenner, and also from the talks given on this topic by him and by Steve Heinemann at the Helmholtz Club on 18 May 1999. My work is supported by the Kieckhefer Foundation <sup>23</sup> .
A framework for consciousness (2003)	We thank P. S. Churchland, D. Eagleman, G. Kreiman, N. Logothetis, G. Mitchison, T. Poggio, V. Ramachandran, A. Revonsuo and J. Reynolds for thoughtful comments, O. Crick for the drawing and the J.W. Kieckhefer Foundation, the W.M. Keck Foundation Fund for Discovery in Basic Medical Research at Caltech, the National Institutes of Health, the National Institute of Mental Health and the National Science Foundation for financial support <sup>24</sup> .

also given preference, when they made 'unusual waves' such as Watson and Crick<sup>12</sup>, Crick and Mitchison<sup>19</sup>, and Crick and Koch<sup>24</sup> in the scientific world.

### Categories of acknowledgement

Hyland<sup>25</sup> had observed that acknowledgements in scholarly texts 'are much more than a simple catalogue of indebtedness. They offer insights into the persona of the writer, the patterns of engagement that define collaboration and interdependence among scholars, and the practices of expectation and etiquette that are involved'. Cronin *et al.*<sup>26</sup> had recognized seven categories of acknowledgement in publications: (1) moral, (2) financial, (3) editorial, (4) instrumental/technical, (5) conceptual, (6) unknown and (7) reader. Among these, journal papers by Crick include five categories: moral, financial, editorial, instrumental/technical and conceptual. An additional category was presentational support. After he became a Nobel laureate, Crick was solicited for quite a range of presentations in his specialty areas. It became a pattern that he made it a habit

to revise the speech text into a journal paper subsequently.

The most predominant category of acknowledgement noted in the journal papers by Crick was for conceptual support solicited by him from his mentors (Lawrence Bragg, Max Perutz and John Kendrew), as well as friends and colleagues. Most recognized names in this category include Alexander Todd, George Kreisel, Jerry Donohue, Maurice Wilkins, A. Elliott, Sydney Brenner, Leslie Orgel, Seymour Benzer, Marshall Nirenberg, Har Gobind Khorana, Graeme Mitchison, Roger D. Kornberg, Aaron Klug, Pierre Chambon, Walter Gilbert, Susumu Tonegawa, Allan Hobson, Christopher Longuet-Higgins, Simon LeVay, V. S. Ramachandran, Patricia Churchland and Terrence Sejnowski.

Moral acknowledgement category relates to the use of unpublished manuscripts, data and photographs of colleagues. As the 'unacknowledged use' of X-ray crystallography patterns obtained by Rosalind Franklin in the deduction of the double-helical structure of DNA in the 1953 *Nature* paper by Watson and Crick became controversial at that time, it appears that Crick was particularly

careful in acknowledging such help from colleagues in his post-1953 publications. Moral acknowledgement category also includes hospitality offered to Crick by senior hosts Honor B. Fell, C. F. A. Pantin and David Harker. Prof. Pantin had allowed the 'use of a room in the Zoological Museum, Cambridge for experiments'<sup>14</sup>.

Financial acknowledgement category provides information about his funding agencies. In his first two papers, Crick had acknowledged Medical Research Council (UK) for a [graduate] studentship. Other funding sources mentioned include Danish Natural Science Research Council, US Air Force, J. W. Kieckhefer Foundation, Eugene and Estelle Ferkauf Foundation, Samuel Roberts Noble Foundation Inc, and System Development Foundation.

Editorial acknowledgement does appear in one future prediction papers by Crick, where the journal *Nature* has been acknowledged by him, for support it had 'given to the development of our subject' (i.e. molecular biology)<sup>27</sup>.

Entries under the instrumental/technical acknowledgment category find occasional mention in the papers by Crick. In

1950s and 1960s, when computer use for long calculations were in its infancy, acknowledgements for this specialty area included sentences such as,

‘The calculations were carried out on IBM machines at the Watson Laboratories, for which facilities we are very grateful.’<sup>28,29</sup>

‘We thank the Computer Laboratory, Cambridge, for providing facilities for us on their Titan computer.’<sup>30</sup>

In two papers<sup>15,24</sup>, Crick had specifically acknowledged the technical help of his wife Odile for drawing the figures. However, such an acknowledgement to his wife’s drawing skill was cavalierly omitted in the 1953 classic report on the Watson–Crick model of DNA<sup>12</sup>. In one paper<sup>31</sup>, acknowledgment was made by names to the breeders or suppliers of *Rhodnius* insect.

An example for presentational support in the acknowledgement category appears as follows: ‘We are indebted to the Organisers of a meeting on Communication with Extraterrestrial Intelligence, held at Byurakan Observatory in Soviet Armenia in September 1971, which crystallized our ideas about Panspermia’<sup>32</sup>.

An unusual type of acknowledgement combining conceptual and financial categories appeared in 1973, in a single-author paper of Crick<sup>33</sup>. For its unusual pattern, the complete text is as follows: ‘The idea arose in conversation with Dr Sydney Brenner, who invented the title “Project K” and whom I have to thank for useful discussions on the topic. This short paper was originally circulated in a European Molecular Biology Organisation (EMBO) document [1] toward the end of 1967. It still seems to me to be an attractive scheme for people of the right temperament, and since EMBO is now unlikely to take it up I thought that it might be useful to give the idea wider publicity.’ What seems peculiar was the phrasing ‘people of the right temperament’.

A reviewer of the previous version of this paper made a valid suggestion that

comparison of the acknowledgement pattern of Crick with one of his contemporaries of equal calibre will be an interesting exercise. Though I agree with this suggestion, such a comparison is beyond the scope of this note, due to space limitation.

### Conclusion

As a metric, acknowledgements have an advantage over citations. Whereas citations can be copied and pasted from one publication to the next by an unscrupulous researcher without being studied in detail<sup>34,35</sup>, acknowledgements cannot be lifted in such a duplicitous style. It is a pity that popular books on writing and publishing a scientific paper offer minimal description on how to write acknowledgements<sup>36</sup>. Thus, I believe this note may serve young students on how to construct acknowledgements for their papers.

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