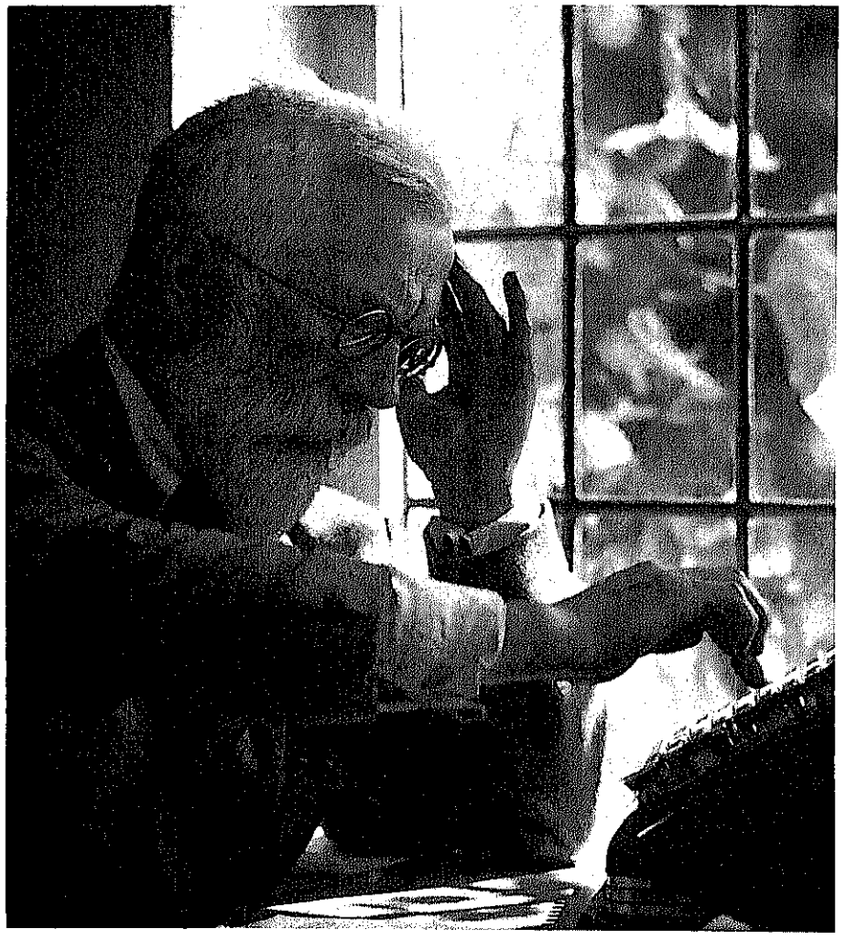

Professor Sir Ronald A. Fisher
(Photograph by Antony Barrington-Brown ARPS.)

Statistical Inference and Analysis

Selected Correspondence of R.A. Fisher

EDITED BY
J.H. Bennett

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Preface

Perhaps no one has had a greater impact on the methodology of scientific research in the twentieth century than Ronald Aylmer Fisher. From his early work in developing statistical methods needed in the interpretation of experimental data, he went on to recast the entire theoretical basis for mathematical statistics and to initiate the deliberate study and development of experimental design central to the whole process of the Natural Sciences. In clarifying the principles of inductive inference—of reasoning from the particular to the general—which Fisher suggested was the only way known to man whereby new knowledge comes into the world, he greatly enlarged our understanding of the nature of uncertainty and contributed fundamentally to the philosophy of our age. In mid-century, Fisher (*CP* 251) ventured to suggest that 'Statistical Science was the peculiar aspect of human progress which gave to the twentieth century its special character'. Fisher was also a distinguished geneticist. His epoch-making book, *The genetical theory of natural selection* (1930), was the first major work to provide a general synthesis of Darwinism and Mendelism. It marked a turning point in the development of evolutionary thought and led to the emergence of neo-Darwinism.

This volume presents a selection from Fisher's letters on statistical inference and analysis and related topics. It also includes relevant material from the letters (many from distinguished scientists) to which Fisher was replying. It is a companion volume to *Natural selection, heredity and eugenics: selected correspondence of R.A. Fisher with Leonard Darwin and others* (ed. J.H. Bennett, Clarendon Press, Oxford, 1983).

The letters in this volume cover the period 1922–62. There are few letters from the first seven years and those involve just two correspondents, Norman Campbell and Percy MacMahon. In the first five years Fisher wrote virtually all of his letters by hand and only rarely kept copies. (Fisher's earliest letter, dated 22 July 1922, to Campbell (p. 58) is one of the few of which he kept a copy in his own hand (see p.60).) Occasionally, when a correspondent had complained that he could not decipher Fisher's handwriting (e.g. MacMahon, p. 276), a typewritten letter would be sent. However, from about 1928 onwards, Fisher's letters were generally typed out by a secretary and then carbon copies were filed away. These copies have provided the basis for the reproduction of most of Fisher's correspondence included in this volume.

Fisher's practice was, wherever possible, to reply to letters immediately after reading them, generally by dictation to his secretary. He had an extraordinary capacity to draw quickly upon his vast mental store of knowledge and ideas; without hesitation, he would recall requisite facts and

marshal the many elements of a complex argument and then express himself with great care and precision. His letters composed in this way were rarely changed later. Sometimes, as when his reply required an extensive mathematical argument or perhaps a very long development, he would write this out by hand for his secretary later to copy on a typewriter. Occasionally he would make small changes to a typed letter before adding his signature and his secretary had then to insert these on the carbon copy before the original was dispatched. In the last few years of his life, when he was often travelling and without secretarial assistance, Fisher resorted again to sending handwritten letters without keeping any copy for his files. In such cases where he filed away a relevant incoming letter, it has sometimes been possible to trace and then obtain photocopies of Fisher's manuscript letters through the generosity of his correspondents.

The correspondence presented in this volume has been arranged in six chapters according to subject matter. Inference (Chapter 1) makes up two-thirds of the volume and Statistical Method (Chapter 2) about one-sixth. The other chapters are History of Statistics, Teaching of Statistics, History and Philosophy of Science, and Scientists and Scientific Research. Within each chapter the letters are ordered alphabetically by the correspondents' surnames. This seemed preferable to a simple chronological ordering because the exchanges with some individuals extend over many years and are best read and studied in their entirety. (In only one instance did it seem necessary to break up a letter with different parts placed in two separate chapters; cross references have been given where this occurs.) My object when selecting correspondence has been to include material of scientific or historical interest, avoiding unnecessary repetition and personal references of no scientific interest. Where a word or passage has been omitted, this is indicated by the symbol . . . . Editorial insertions in the correspondence are shown within square brackets [ ]. References to books and papers by Fisher have been inserted wherever it was thought this could be helpful. The numbering system used for references to Fisher's papers is that adopted in the *Collected papers of R.A. Fisher*.* Readers seeking further understanding of Fisher's work may be referred to the article by F. Yates and K. Mather in *Biographical memoirs of Fellows of the Royal Society of London*, **9**, 91–120 (1963)† and Joan Fisher Box's biography of her father: *R.A. Fisher, the life of a scientist* (Wiley 1978). L.J. Savage's article 'On re-reading R.A. Fisher' (*Annals of Statistics*, **4**, 441–500, (1976)) is also recommended.

An important part of the correspondence in Chapter 1 was produced in 1954–55 whilst Fisher was preparing the manuscript of *Statistical methods and scientific inference*. At various stages he invited Frank Yates and George Barnard to Cambridge to discuss what he had written and some of the correspondence in Chapter 1 stemmed from those discussions. There is much of interest in Fisher's correspondence with all of the distinguished statisticians represented in Chapter 1. However, special mention might be made of (i) the

long series of exchanges with Jeffreys in Cambridge, covering virtually the whole of Fisher's period at the Galton Laboratory and ceasing when Fisher returned to Cambridge in 1943 and (ii) the remarkable series of exchanges on fiducial inference (a) with Darmois and Fréchet in Paris in 1940, (b) with Savage and Tukey in USA in the period 1952–55, and (c) in the last months of Fisher's life, with Barnard, Finney, Fraser, A.T. James, Kyburg, Rao and Sprott. Chapter 2 contains many delightful examples of Fisher's eager approach to finding innovative and elegant solutions to various problems involved in the handling of experimental data. We may also note in Chapter 2 his interest in and concern with computation and in the following chapters his comments on the origin of some statistical terms and symbolism as well as his interesting views on more general questions such as the organization of scientific research and freedom in science. His writing throughout is sharp-edged and stimulating. Whilst lightened by many good-humoured comments, it needs to be read very carefully.

As indicated in the earlier volume of Fisher's scientific correspondence as well as in *R.A. Fisher, the life of a scientist*, Charles Darwin's son Leonard (1850–1943) had a profound influence on Fisher's life and work. Leonard's advice was often sought by Fisher early in his career and, when given, it was always greatly respected. After Fisher's major paper on the correlation between relatives had been effectively rejected by the Royal Society of London and then the Royal Society of Edinburgh had said it could only publish a short abstract, it was Darwin's intervention that led to publication of the full paper. When some of Fisher's early papers were refused publication in *Biometrika* and the *Journal of the Royal Statistical Society*, Darwin gave Fisher wise counsel and assistance. It was in such circumstances that Darwin wrote to Fisher in 1923 urging him to 'push on quietly avoiding as far as possible all controversy'. Darwin strengthened his appeal by adding that his father had believed controversy with individuals was a great waste of time and should be avoided. However, Fisher found himself unable to follow this advice for very long. As many of his innovative ideas and developments became controversial, he could not resist being drawn into the fray. With his great intellect and ready wit, he could have a devastating effect in scientific controversy, though it must be said, as Fisher himself recognized, that he sometimes became an irascible protagonist. In his correspondence also he was sometimes inclined to be rather testy but it seems that generally, if he believed a correspondent genuinely shared his aim of getting at the truth or of making some progress in understanding, then he would happily make a great effort to help, although sometimes this might be through prodding the correspondent to think for himself, possibly along suggested new lines.

In his obituary notice on 'Student', Fisher remarked on his clear-headedness, his custom of forming independent judgements, his concern with and responsibility for the practical interpretation of experimental data, his constructive imagination and pertinacity, and his ability to perceive and to

solve his problems. These characteristics were also typical of Fisher and they can be seen in his correspondence. Fisher was, in addition, a most able mathematician with deep insight into the subject, but he never lost contact with real data. He only published mathematical work that bore on statistical or genetical theory and only when it could be used to analyse data or solve practical problems. His profound mathematical insight sometimes caused difficulties for readers of his work because he could take a short cut using the geometry of generalized Euclidean space which was very elegant but not easy to follow. He considered that the breadth of logical outlook essential in inductive inference was only easily acquired by long contact with experimental research and it was his belief that mathematicians often lacked this that led him to be highly critical of the influence of mathematicians on statistics. This is a sentiment that appears in a number of his letters.

I am greatly indebted to three of Fisher's colleagues and friends for their invaluable assistance in the preparatory work associated with this volume. Frank Yates, David Finney, and George Barnard have made many helpful suggestions and kindly provided answers to various questions that arose in the course of this work. David Finney visited Adelaide, with support from the University of Adelaide Distinguished Visiting Scholar Scheme, to assist with the final selection of correspondence and its general arrangement. I am grateful to Graham Wilkinson for his help especially with the correspondence on inference and to Alan James for his advice on many questions relating to this volume. Special thanks are due to the authors of correspondence with Fisher, or their literary executors, for permission to quote material from letters addressed to Fisher. I am indebted to Donald Fraser, Henry Kyburg, and David Sprott for providing photocopies of manuscript letters they received from Fisher in 1962. I am indebted to George Barnard for drawing the Fisher–Sprott correspondence to my attention; Sprott's letters to Fisher, some of which were posted to India, did not get into Fisher's files in Adelaide and were apparently lost. I thank the University of Adelaide for permission to quote extracts from *R.A. Fisher Correspondence* held at the University and the Royal Society of London for permission to quote part of a report that Fisher wrote for the Society in 1934. I also wish to thank Miss Georgette Psaltis and Mrs. S.E. Suter for the care with which they prepared the typescript.

J.H.B.

Adelaide, South Australia
February 1989

Contents

Editor's Abbreviations

CP *Collected papers of R.A. Fisher* (ed. J.H. Bennett). Volumes 1–5. University of Adelaide (1971–4). (Numbered references to papers can be identified from the reference list on p. 369.)

CMS *Contributions to mathematical statistics* by R.A. Fisher. John Wiley, New York (1950).

DOE *The design of experiments* by R.A. Fisher. Editions 1–8, Oliver and Boyd, Edinburgh (1935–66). Eighth edition reprinted by Hafner Publishing Company (1971).*

GTNS *The genetical theory of natural selection* by R.A. Fisher. Clarendon Press, Oxford (1930). Revised edition, Dover Publications, New York (1958).

SMRW *Statistical methods for research workers* by R.A. Fisher. Editions 1–14, Oliver and Boyd, Edinburgh (1925–70). Fourteenth edition reprinted by Hafner Publishing Company (1973).*

SMSI *Statistical methods and scientific inference* by R.A. Fisher. Editions 1–2, Oliver and Boyd, Edinburgh (1956–9). Third edition, Hafner Publishing Company (1973).*

ST *Statistical tables for biological, agricultural and medical research* by R.A. Fisher and F. Yates. Editions 1–6, Oliver and Boyd, Edinburgh (1938–63). Sixth edition reprinted by Longman (1974).

Page numbers given for Fisher's books in the editorial notes in the present volume refer to the most recent editions unless otherwise stated.

*Reprinted by Oxford University Press (1990) in one volume, *Statistical methods, experimental design and scientific inference*, with a Foreword by Frank Yates.

Dates and Events in the Life of R.A. Fisher

1890	Born on 17 February in London.
	Educated at Stanmore Park and Harrow Schools.
1909–13	Student at University of Cambridge.
1912	B.A. (Camb.), having passed the Mathematical Tripos Part II as a Wrangler.
1913–14	Statistician in Mercantile and General Investment Company, London.
1914–18	Assistant Master at Rugby and other schools.
1917	Married to Ruth Eileen Guinness.
1919–33	Statistician, Rothamsted Experimental Station, Harpenden.
1920	M.A. (Camb.).
1921–27	Fellow, Gonville and Caius College, Cambridge.
1925	Publication of *Statistical methods for research workers.*
1926	Sc.D. (Camb.).
1929	Fellow of the Royal Society.
1930	Publication of *The genetical theory of natural selection.*
1933–43	Galton Professor of Eugenics, University College, London.
	Editor of *Annals of Eugenics.*
1934	Honorary member, American Academy of Arts and Sciences.
1935	Publication of *The design of experiments.*
1937	Honorary Fellow, Indian Statistical Institute.
1938	Publication of R.A. Fisher and F. Yates's *Statistical tables for biological, agricultural and medical research.*
	Royal medal of the Royal Society.
1943–57	Arthur Balfour Professor of Genetics, University of Cambridge.
1943–62	Fellow, Gonville and Caius College, Cambridge.
1946	Guy medal of the Royal Statistical Society.
1947	With C.D. Darlington, founded the international journal *Heredity*; co-editor, 1947–62.
1948	Darwin medal of the Royal Society.
	Foreign associate, U.S.A. National Academy of Sciences.
	Foreign member, Royal Swedish Academy of Sciences.

1949	Publication of *The theory of inbreeding.*
1950	Foreign member, Royal Danish Academy of Sciences and Letters.
	Publication of *Contributions to mathematical statistics.*
1952	Knight Bachelor.
1955	Copley medal of the Royal Society.
1956	Publication of *Statistical methods and scientific inference.*
1956–59	President, Gonville and Caius College, Cambridge.
1958	Silver medal of the Linnean Society.
1959–62	Research Fellow, CSIRO Division of Mathematical Statistics, University of Adelaide, South Australia.
1961	Member of the Pontifical Academy of Sciences.
1962	Died on 29 July at Adelaide, South Australia.

Ronald Aylmer Fisher†

The frailties of Ronald Fisher's mortal existence have succumbed, but his scientific spirit will live forever in his published researches, indelibly inscribed across the pages of 50 years in the history of science.

To do full justice to the man and his accomplishments is a task for another time and place, and I have thought it fitting for this occasion to emphasize what seem to me to be outstanding points.

During the latter half of 1918, he was offered two posts almost simultaneously: the first, as senior assistant to the Professor in the Galton Laboratory, University College, London, a centre with an established reputation in mathematical statistics and biometry, and the second, at Rothamsted Experimental Station, where he would have to make his own way.

It must be remembered that up to that time he had only a few papers to his credit, including two which were most important, one in mathematical statistics, and the other in genetics—the two fields in which he ultimately made his greatest contributions.

In characteristic fashion, young Fisher decided to stand on his own feet, and accepted the Rothamsted post. He knew exactly what he was doing, because he foresaw the opportunities for independent research. It was a momentous decision. At that time the experimentalist, in particular the biologist, struggled with research under the severe handicap of biological variation, with only small samples and limited facilities for increasing his observations.

Within five years, Fisher had solved all major problems, and placed in the hands of the experimenter both the techniques for conducting the experiments and the mathematical and arithmetical procedures for making sense of the results.

These researches were gathered together in a book first published in 1925. The effect was electrifying. Word rapidly encircled the globe, and a stream of men converged on Rothamsted to learn at first-hand something of these new developments for application in their respective countries. I emphasize how widely these ideas were spread, and to indicate how deeply they penetrated, I may mention that they even provided material for examination questions as presented to students of agriculture in the University of Melbourne. All this in the space of as many years as can be counted on the fingers of one hand! This is no exaggeration; it is fact, because I was one of those students.

The book, *Statistical methods for research workers*, is without doubt a classic, and made a tremendous impact on science. In 37 years it has gone to

† The address given by Professor E.A. Cornish at the funeral of Sir Ronald Fisher in St Peter's Cathedral, Adelaide, 2 August 1962.

the 13th edition, with a complete reprint of one edition, making the equivalent of 14. Moreover, there are translations in French, German, Italian, Spanish, Russian, and Japanese.

In mathematical statistics, success mounted on success, until today every phase of the subject bears his mark, and in most of them he laid the foundations. Two more books followed on the theory of statistics—the first now in its seventh edition, with translations to other languages, and the second (his latest) in its second edition. And all this had its origin in the fact that he was the right man, at the right time and in the right place.

In genetics his total contribution falls not far short of that in mathematical statistics, but it did not hit the scientific world with the same impact, nor did it spread in the same dramatic manner. There was, however, one very great moment. For many years he had been working on a series of researches of which the outside world knew nothing until publication, in 1930, of the book *The genetical theory of natural selection*, which can be most suitably appraised by stating that it provided a quantitive basis for the Darwinian theory, just as Clerk–Maxwell's electromagnetic theory of light provided the quantitative basis for Faraday's work in experimental physics.

Recognition came with numerous honours; honorary degrees from universities in Britain, USA, India, and Australia; election to national academies in Britain, USA, Sweden, Denmark, and the Pontifical Academy, and a Knight Bachelor from Her Majesty the Queen.

As to the man himself, an outstanding characteristic was his immense capacity for work—aside from his books, his personal contribution totalled between 300 and 400 research papers, but to this must be added an incalculable contribution to the research of literally hundreds of individuals, in the ideas, guidance, and assistance he so generously gave, irrespective of nationality, colour, class, or creed.

This was made possible, first, by his extraordinary insight and acumen which immediately stripped each problem down to its essentials, and secondly, by the innate ability—intuition if you wish—to proceed unerringly to the solution. Two characteristics, I submit, which mark the touch of genius.

The breadth of his knowledge beyond his chosen fields seemed boundless—he could speak with authority on literature and ancient history (in particular ancient civilizations), and in a sense at the other extreme, on continental drift and palaeomagnetism.

His English, both written and spoken, was impeccable; when he chose he was an excellent lecturer; he was always brilliant in conversation, a deadly opponent in argument, completely intolerant of humbug, and like all of us, he had his little idiosyncrasies.

But he was a kindly soul, most inspiring and encouraging to those who genuinely sought his aid, and intensely loyal to his staff and students—as witness the tremendous fight he waged for the scientific reputation of a young Indian cotton researcher.

He had an abiding interest in nature in all its forms. He loved children and they were always attracted to him. And on this note I should like to conclude by relating a touching little incident. We are all familiar with the uninhibited vocal efforts of children at play. The pupils of the school in the immediate vicinity of the Queen Elizabeth Hospital will never know how their cries delighted him during last week as he lay fighting to keep alive the flickering candle of life.

He must go down in history as one of the great men of this our twentieth century.

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