Whittle, Peter (1927-2021), mathematician and statistician, was born on 27 February 1927 in Wellington, New Zealand, the eldest of the three children of Percy Whittle (1898-1971) and his wife Elsie, née Tregurtha (1905-1993). His father, born in Christchurch, New Zealand, was an orphan, joined the Post Office as a telegram delivery boy, and rose to become assistant postmaster for Wellington. Peter's mother, born in Wellington, New Zealand, became a schoolteacher and married Percy in 1926.

Peter Whittle spent his first twenty-two years in the spectacularly beautiful Island Bay, south of Wellington, facing onto Cook Strait. He enjoyed considerable success at school, being dux of Wellington Boys' College in 1944. He graduated from the University of New Zealand with a BSc in mathematics and physics in 1947, coming first in the whole of New Zealand in the examinations for these subjects, followed by an MSc in mathematics in 1948. He intended a career in mathematical physics, but vacation work in the NZ Department of Scientific and Industrial Research (DSIR) offered statistical problems from agriculture and biometrics that attracted his scientific interest, and his first paper was on the design of experiments. At this stage his statistical training came from texts and especially Maurice Kendall's encyclopaedic *Advanced Theory of Statistics*, whose unified theoretical coverage and clear and economic literary style left a lasting impression.

A travelling scholarship in 1949 took Whittle to Uppsala, Sweden, for his doctoral work under Hermann Wold. A profound influence was Maurice Bartlett, then working in Manchester. Whittle began his work on time series analysis, and in his doctoral thesis and four papers following on from it he essentially solved the large-sample inference problem for a stationary time series generated by a linear Gaussian model. The terms 'multivariate Whittle likelihood' and 'Whittle estimation' became common, but this early groundbreaking work was not at the time widely appreciated: Whittle remarked that, perhaps in unconscious emulation of the admired Bartlett, he wrote too gnomically. In marked contrast his corresponding analysis for spatial processes, published in 1954, had an immediate and sustained impact. His asymptotic inference theory for Gaussian processes and related spatial processes was ahead of its time in considering power law covariance functions, which later became central in image analysis.

After Uppsala, Whittle returned in 1953 to New Zealand and the DSIR. The subsequent six years were to be deeply formative. Work on New Zealand rabbits (pests of the first order) produced the Whittle threshold theorem for stochastic process models of an epidemic. Oscillations in oceanographic data (from the Island Bay rock channels) uncovered non-linear effects. His time-series work led into the study and statistical analysis of spatial models, observing spatial autocorrelation functions that behaved as inverse powers in their tails; fractals and self-similar processes were as yet unthought of. During this period he also became interested in polymerisation and in reversibility, both topics he would return to later. Whittle believed that his subsequent interests and career were largely shaped by his time in the NZ Department of Scientific and Industrial Research, working on problems from geophysics, agriculture, and industry. His superior there later wrote, 'His genuine interest in people and their work, his admiration for other's achievements, his boyish sense of humour and lack of pretension, made it possible for him to carry his own intellectual pre-eminence without exciting jealousy or antagonism' (Williams, 'Introductory note').

Whittle came back to the UK in 1959 as a lecturer in the Statistical Laboratory, University of Cambridge, where his colleagues were Dennis Lindley and Maurice Walker, and where his research students included John Bather and John Kingman. In 1961 he moved to the chair of mathematical statistics at the University of Manchester, succeeding Bartlett and with David Silvey and Toby Lewis as colleagues, and with Henry Daniels in Birmingham as a kindred spirit. Whittle's interest in optimization developed at Manchester; he kept his interest in spatial processes, with his student

David Brook producing an early result on Markov random fields; and he obtained his first results on networks of queues and partial balance.

In 1967 Whittle returned to Cambridge as the Churchill professor of mathematics for operational research, a newly established chair endowed by Esso through the active management of David Kendall. The position gave Whittle the perfect platform for his vision that what needed developing was not just narrow-sense operational research, but the whole area of what in Cambridge was termed applicable mathematics. This included, for example, probability, statistics, optimization, game theory, and those aspects of disciplines such as control theory, communications theory, and mathematical economics which might be pursued by someone technically based in probability and optimization. Developments in the US had convinced Whittle not only of the practical importance of these topics but also of the depth and coherence of the theory they generate. He felt that the subject of statistics itself is thoroughly penetrated by optimization concepts and is only viewed aright when embedded in this larger context (a view later taken for granted in statistics generally and in areas such as machine learning). He set about the task of creating the new courses to deliver this vision, and this began an evolution of the mathematical tripos at Cambridge that continued thereafter. He served as director of the Cambridge Statistical Laboratory from 1973 to 1986.

Whittle wrote many important papers, but it is in his books that one can best appreciate the broad sweep of his achievements and the simplicity, unity, and generality of his approach. His twelve major volumes covered times series, prediction, constrained optimization, dynamic programming, optimal control, stochastic systems, the foundations of probability theory, and neural nets. Several of these works were ahead of their time; indeed, some of his early works appear to have been written for a later audience, such is the extent to which they anticipated subsequent developments.

By the time of Whittle's second major work on time series (*Prediction and Regulation*, 1963, revised second edition in 1983) – his first was his doctoral work – his interest had moved from inference to prediction and control. His four volumes on optimization marked his continuing interest in stochastic control, and in temporal optimization generally, using dynamic programming ideas. *Optimization under Constraints* (1971) is shot through with insight in a prose style combining power and economy. Notable in *Optimization over Time* (1983) is Whittle's treatment of the multi-armed bandit problem. Despite its whimsical name this problem – the sequential allocation of effort in the presence of uncertainty – arises in areas as varied as the design of clinical trials or the choice of exploration avenues in artificial intelligence. Later, in *Risk-Sensitive Optimal Control* (1991) the very complete theory for the linear/quadratic/Gaussian case is transferred to a significantly more general case.

Whittle's vision for the whole area of applicable mathematics was by now well established, providing the mathematical foundations for central areas of engineering and economics. Mathematicians often do not see the impact of their work on other fields. It is noteworthy that in the foreword to the second edition of *Prediction and Regulation,* Thomas Sargent, later awarded the Nobel prize in economics for empirical research on cause and effect in the macroeconomy, wrote on the importance of Whittle's work for understanding dynamic economic phenomena.

Whittle's book *Probability via Expectation* (1970, expanded in 2000) was an exposition of probability theory which formulated its axioms in terms of expectation rather than measure, developing Whittle's view that this approach has advantages at many levels. One advantage is that probability theory and probability of quantum theory are seen to differ in only a modification of the axioms – a modification rich in consequences, but (as in so much of his work) succinctly expressible. The book was published in Russian in 1982, quite a compliment in view of the special role Russian authors played in the development of probability theory.

Whittle had a lifelong interest in statistical/physical models, and the book *Systems in Stochastic Equilibrium* (1986) collected as one of its parts his work on polymerization and random graphs, and his work on partial balance in networks. His work on networks continued with *Neural Nets and Chaotic Carriers* (1998) and *Networks: Optimization and Evolution* (2007). In his final years he maintained his interest in neural nets, finding the notions of self-optimizing and self-organizing systems both fascinating and of enormous potential. But even he might have been surprised to see the pace of the realignment of mathematics, with statistics, optimization, and machine learning permeating applied mathematics and leading to remarkable advances across swathes of physical, biological, and social science.

Whittle was awarded the Royal Statistical Society's Guy medal in silver in 1966 and in gold in 1996. Other distinctions included the Sylvester medal of the Royal Society, and the Lanchester prize and the John von Neumann theory prize of the Institute for Operations Research and the Management Sciences. He was elected a fellow of the Royal Society in 1978 and an international member of the US National Academy of Engineering in 2016.

Whittle married Käthe Blomquist in 1951, and they had six children (and eventually seven grandchildren and one great granddaughter). Käthe was Finnish and they had met in Uppsala. They did their courting in Swedish, a second language to each and their only common language. He sometimes described himself as a 'loner' and as far as his academic work was concerned he was certainly refreshingly away from the crowd. But it is hard to think of anyone who took such pleasure from his large family as really alone. The keenness of Whittle's observation of personalities was another factor – to be read so clearly could be disconcerting.

At school in New Zealand Whittle played the flute in the school orchestra, and he got pleasure from making and playing instruments throughout his life. He was particularly attracted to woodwind instruments, especially the oboe. In his middle years he learned the flamenco guitar, mastering the *rasgueado* – the continuous drum-roll achieved with the backs of the fingernails. He played the chanter – the part of the bagpipes that creates the melody, without the bag and drones. Languages were another interest: French, Swedish, and Russian early in his life, and after retirement Scottish Gaelic, whose evocative charms fascinated him. He was a talented runner (achieving 4 minutes 36 seconds for the mile) and kept up distance running into his later years. He enjoyed carpentry, general DIY, and toymaking, finding them a useful counterweight to his academic work. Music was all around the family, from Irish drinking songs, keening Gaelic laments, Swedish love songs, and Māori hakas, to Bach concertos and Sibelius symphonies, reflecting not only the breadth of Whittle's aesthetic sense and the richness of his mind, but also the shifting aspects of his interior life and personality. The music of Ravel, particularly, with its precision, refinement, and elegance, accorded well with his mathematical mind.

Whittle had particular reasons to investigate his family history, and in his later years he assembled a rich account of his nineteenth-century British and Irish extraction. His most distinguished ancestor was his great-grandfather, James Whittall (1827-1893), at one time taipan for Jardine Matheson in Hong Kong and founder in Ceylon of the eponymous tea business. Whittall's eldest son, Whittle's grandfather, stood in sad contrast, and so shamed his father that he was disinherited: his son, raised in an orphanage, was Whittle's father.

Whittle died at his home, 268 Queen Edith's Way, Cambridge, on 10 August 2021 from Alzheimer's disease. His wife Käthe had died in 2020. They were survived by their children, Martin, Lorna, Miles, Gregory, Jennifer, and Elsie. Throughout his life he greatly missed New Zealand and asked that his ashes be cast into the waters of Island Bay, which he had grown up overlooking.

Frank Kelly

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Likenesses

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