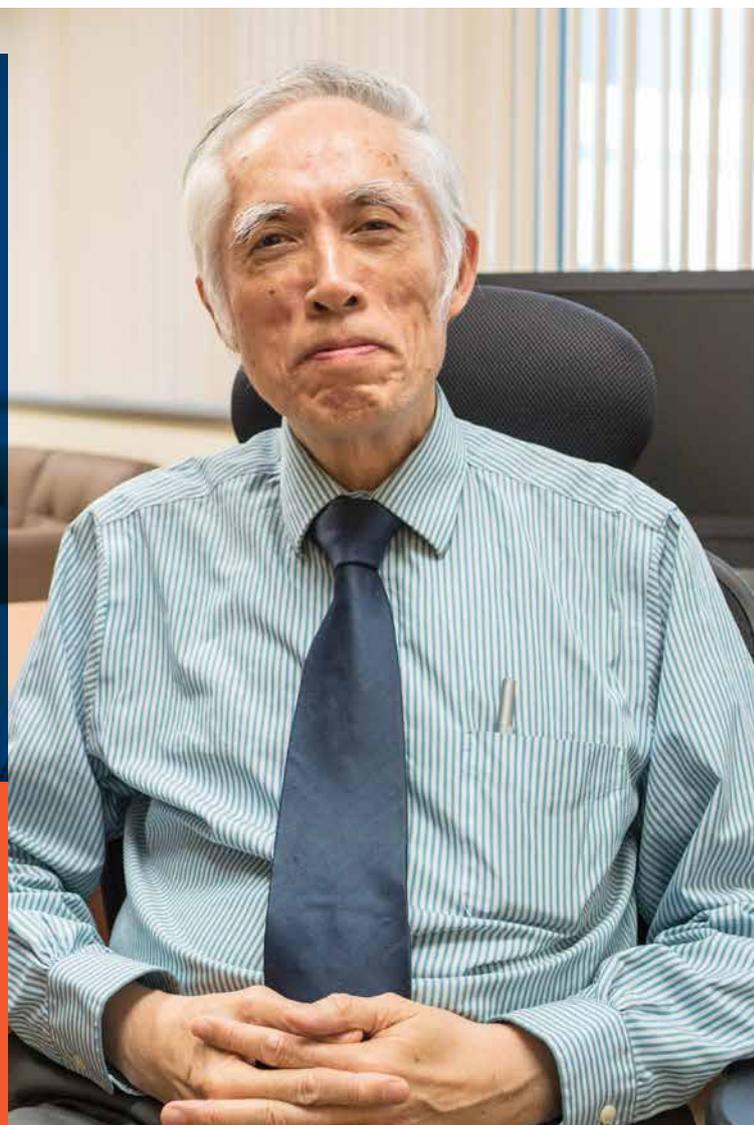


# TZE LEUNG LAI:

FROM ACCIDENTAL  
STATISTICIAN TO INTER-  
DISCIPLINARY STATISTICIAN  
WHO COMBINES THEORY  
WITH PRACTICE

**Interview of Tze Leung Lai  
by Y.K. Leong**

Tze Leung Lai is well-known for his far-reaching contributions in sequential statistical analysis and wide-ranging applications in engineering, finance and biomedical sciences.



Starting with a reluctant switch from economics to mathematics in his early undergraduate years, Lai graduated with first class honours in mathematics from the University of Hong Kong (HKU). After a one-year stint as demonstrator in mathematics in HKU, he went to Columbia University for graduate study in statistics essentially out of convenience in an application process. Subsequently, again as a matter of convenience, he stayed and taught at Columbia for 16 years. Destiny has it that while he was teaching a new course on time series in his early faculty years, he was accidentally roped in as a statistical consultant into a medical project on the sudden infant death syndrome in the Pediatric Pulmonary Division of the Columbia Presbyterian Medical Center. This marked the beginning of an enduring interest and prolific contribution to multidisciplinary research in a wide spectrum of areas in the biomedical sciences, engineering and financial mathematics.

He has published over 300 papers and 12 books, and has supervised 74 Ph.D. theses at Columbia, Stanford, and Stony Brook and University of Padova in Italy (where he visited). He has served on the editorial boards of leading international journals such as *Journal of the American Statistical Association*, *Zeitschrift für Wahrscheinlichkeitstheorie und Verwandte Gebiete*,

*Probability Theory and Related Fields*, *Statistica Sinica*, *Annals of Mathematical Sciences and Applications*, *Sequential Analysis*, *Journal of Statistical Planning and Inference*, and *Journal of Multivariate Analysis*.

Among his many contributions to sequential statistical analysis is the development of a comprehensive theory of sequential tests of composite hypotheses, unifying previous approaches and providing far-reaching extensions to cope with the practical complexities that arise in the applications to group sequential clinical trials. He has also done ground-breaking work in (i) the solution of the long-standing “multi-armed bandit problem”, (ii) stochastic approximation and recursive estimation, (iii) adaptive control of linear stochastic systems and Markov decision processes, (iv) saddlepoint approximations and boundary-crossing probabilities in Markov random walks and random fields, and (v) survival analysis.

He was Higgins Professor of Mathematical Statistics before moving to Stanford University in 1987 as Professor of Statistics. During the past three decades at Stanford, he served as Director of the Interdisciplinary Program in Financial Mathematics and Co-director of the Biostatistics Core, Stanford Cancer Institute. Currently, he is the Ray Lyman Wilbur Professor of Statistics and by courtesy, also

of Biomedical Data Science and of Computational and Mathematical Engineering. His capacity and energy for multidisciplinary work is legendary, as can be seen in the numerous hats he is now wearing: Director of Financial and Risk Modelling Institute (FARM), Co-director of the Center for Innovative Study Design (CISD) and core member of the Comprehensive Cancer Institute, Center for Innovation in Global Health, Center for Precision Mental Health and Wellness, and Center for Population Health Sciences in the School of Medicine.

Since the late 1980s, Lai's tireless efforts have also made their imprints on the development of the statistical sciences in China. He is also the honorary dean of the Center for Financial Technology & Risk Analytics at Fudan University, a visiting chair professor of Southwestern University of Finance and Economics, and an advisory committee member of the Yau Center for Mathematical Sciences at Tsinghua University, the Center for Statistical Science at Peking University, the Department of Statistics and Actuarial Science at the University of Hong Kong and the Institute of Statistical Science, Academia Sinica in Taiwan. Notable among the numerous honours and awards he received is the prestigious COPSS Presidents' Award, the annual award given by the Committee of Presidents of Statistical Societies (COPSS) to statisticians below the age of 41 and sometimes referred as the "Nobel Prize of Statistics".

Lai's association with the National University of Singapore (NUS) dates back to 1989-1993 when he was its external examiner in mathematics. He is an old friend of Louis Chen, former director of NUS's Institute for Mathematical Sciences (IMS) and was the Ph.D advisor of Hock Peng Chan and Tiong Wee Lim, respectively the current Head and a Deputy Head of NUS's Department of Statistics and Applied Probability (DSAP). Lai visited DSAP in January–March 2017 as Saw Swee Hock Visiting Professor and was back again at NUS for the IMS program on Statistical Methods for *Developing Personalized Mobile Health Interventions* (11 February – 1 March 2019) in which he gave two IMS Distinguished Visitor Lectures on (i) *Real World Data, Real World Evidence, and Decision Analytics for Precision Medicine and Health*, and (ii) *Latent State Modeling in Mobile Health and Diagnostic Classification: Recent Advances in the MCMC Approach*.

During his visit to DSAP, he was interviewed on 15 February 2017 by Y.K. Leong on behalf of *Imprints*. This was updated by an email interview on 1 March 2019 when he was visiting IMS. The following consists of two parts. Part I is an edited and enhanced version of the transcript of the interview on 15 February 2017, and Part II is an updated email interview given during his second visit to NUS in March 2019. Part I describes in vivid details how he became a statistician "by accident" while Part II describes his multidisciplinary work and, in particular, his involvement with AI (artificial intelligence) in medicine and finance.

## Part I. The Accidental Statistician

**IMPRINTS** **I** As an undergraduate at The University of Hong Kong, your declared major was originally economics, but you later switched to mathematics. Why did you switch to mathematics?

**TZE LEUNG LAI** **L** First of all, I must tell you about the University of Hong Kong (HKU) in those days because it was very unlike now. I entered HKU in 1964. At that time it was the only recognised university in Hong Kong. Then later, after I graduated, The Chinese University of Hong Kong (CUHK) became the second university. In my days, not everybody had to go to the university to get a very good job, but a degree from HKU could serve as a "licence" for certain high-level jobs.

**I** I think most of the university graduates end up as civil servants.

**L** Yes. That was why I declared economics as my major. *[Laughs]* Actually I didn't really intend to go to the university. You probably know that Donald Tsang, the second governor of Hong Kong (after it became the Special Administrative Region of China), did not go to the university. He became a civil servant very early and rose through the ranks. After he held several positions in finance and trade as Chief Executive Officer, he was sent

by the British colonial government in 1981 to the Kennedy School of Government at Harvard, where he received a master's degree in public administration before returning to Hong Kong. I was in Tsang's age group albeit nine months younger.

When I was in Form 6 (Lower 6 and Upper 6 – it's the British system), I could have studied science, which most of my classmates did, but I took up arts just to build up my language skills and also because I didn't have to work that hard. *[Laughs]* I applied to the Housing Authority when I was in Upper 6, but I was not selected. It was too late to apply to the university, so I taught at a private school for a year and that was when I acquired my teaching skills. It was in the following year that I entered the university to study economics in the Faculty of Arts. The Faculty of Medicine was the most glamorous at HKU in those days, followed by engineering, science and arts in that order. The first-year examination consisted of four papers (subjects). I wanted to major in economics; hence I took economics and statistics. The two other subjects were (a) first-year mathematics and (b) history of mathematics and number theory. The most difficult subject was first-year mathematics because I did not have the background as I could not attend mathematics classes in Form 6 and relied on self-study to pass the Matriculation Examination in mathematics that I registered for. When I was in Form 6, I had to attend English literature classes for the arts students, which were held at the same time as mathematics classes for the science students. I asked

my teacher, a Scotsman, whether I could attend some mathematics classes and read English literature on my own. He answered that he would think about it. The next day, when he was lecturing on Shakespeare's *Twelfth Night*, in which Lady Olivia's steward Malvolio had "conceited" fantasies of marrying Lady Olivia. To explain what the word "conceited" means, my teacher used me as an example: "One of you asked me yesterday whether he could skip some of my classes to attend classes in mathematics for the science students. English Literature is already a difficult subject and one needs to attend all classes and spend a lot of time reading and writing essays to do well. Mathematics is even harder. Thinking that he can do both with only partial effort is an example of being conceited." [Laughs] Since his implicit answer was no, I modified my "conceit" by studying a minimal amount of mathematics to pass the subject that I had registered for the Matriculation Examination. Basically, I focused on differentiation and gave up integration in studying for the examination. Despite this weak background, I enjoyed my first-year mathematics course but found the economics course somewhat disappointing.

**I** Why?

**L** Because it was too soft.

**I** Descriptive?

**L** Yes, it was too descriptive. The instructor Lee Goodstadt, who received his diploma in agricultural economics from Oxford and master's degree in economics from Manchester, came to Hong Kong as a Commonwealth Scholar in 1962 and joined HKU in 1964 when I entered the university. He did not have much teaching experience but had to face a large class of over a hundred freshmen. He had difficulties in explaining indifference curves and the law of marginal returns to many bewildered students and I tried to help him out by suggesting the use of differential calculus and concave functions. He was visibly upset with my unsolicited suggestion. He paid me back by being unfairly critical of my essay in that week's tutorial session. This made me switch to mathematics as my major. I made up for my aforementioned weakness in background by working very hard and benefiting from the excellent tutorial sessions in my mathematics course. I even won the first prize in the Arts Faculty at the end of my first year because of top scores in the examinations of the four papers (including economics). Actually, I began to like Goodstadt's lectures after he finished microeconomics and moved to his areas of expertise – theory of land, which was very relevant to the rising housing prices in Hong Kong, and money and banking, which was very timely because there was a series of bank runs in 1965 following the bankruptcy of Canton Trust and Commercial Bank on February 8, 1965. Goodstadt and I later got along well, and he became the deputy editor of *Far Eastern Economic Review* from 1966 to 1976 and the editorial director of *Asiabanking* from 1981-1986. He left HKU to be head of the newly established

**“WHEN I LOOK BACK ON MY CAREER, I FEEL EXTREMELY FORTUNATE IN HAVING SEVERAL GREAT TEACHERS AND MENTORS, AND PROFESSOR [YUNG-CHOW] WONG IS ONE OF THEM.”**

Central Policy Unit in 1989 and was later awarded CBE [Commander of the Most Excellent Order of the British Empire] by Queen Elizabeth II and Justice of Peace by the governor of Hong Kong. Winning the first prize in the Arts Faculty first-year examinations boosted my confidence in taking all nine papers in mathematics (including two papers in applied mathematics, for which I chose statistics) for my examination in the final year; we did not have examinations in the second year. I won the top prize in the Faculty of Arts and the Walter Brown Memorial Prize in Mathematics and graduated from HKU with B.A. (First Class Honours), preparing me for my dream job of joining civil service as an Administrative Officer.

**I** Why did you go overseas to study instead of joining civil service?

**L** The end of my final-year examinations in May coincided with the beginning of the 1967 leftist riots in Hong Kong, marked by labor disputes in taxi, textile and cement companies, in particular demonstrations against the factory Hong Kong Artificial Flower Works, where pro-communist trade unionists set up picket lines that clashed with management, who called in riot police on May 6 that led to violent clashes, resulting in the arrests of 21 picketing workers and many more injuries. Many large-scale demonstrations erupted on the streets of Hong Kong the following days, and the winds of Cultural Revolution had already blown to Hong Kong. The leftists formed the Hong Kong and Kowloon Committee for Anti-Hong Kong British Persecution Struggle on May 16, and put up posters on walls with slogans such as "Down with British Imperialism", "Stew the White-Skinned Pigs" (referring to the British rulers) and "Fry the Yellow Running Dogs" (referring to the local yellow-skinned civil servants working for the British colonial government). Hence my dream job of joining civil service as an Administrative Officer suddenly became unattractive and even dangerous. Fortunately, switching from economics to mathematics had huge payoffs in those tumultuous times. Professor Yung-Chow Wong, head of the Mathematics Department and one of the most distinguished professors at HKU, called me and asked if I would like to take an opening in the Department as Demonstrator (corresponding to Tutor in British universities) of Mathematics. He also congratulated me on my performance in the examinations and winning the prizes. I expressed my deep gratitude to him and thereupon began my long career in academia instead of joining civil service.

My job as Demonstrator of Mathematics began in September 1967 and lasted for a year. I was assigned to be the assistant of Professor Wong in his course on calculus on manifolds for third-year B.A. and B.Sc. special students in mathematics. He used a book with the same name by Michael Spivak. I learned a lot on differential geometry from him during that year, which many years later benefited my research that resulted in a series of joint papers on large deviation and saddlepoint approximations for generalized likelihood ratio statistics, Markov random walks, and asymptotically Gaussian random fields, from 2000 – 2006 with my former Ph.D student Hock Peng Chan, who is the current chair of the Department of Statistics and Applied Probability at NUS.

Professor Yung-Chow Wong came from Sun Yat-Sen University to HKU to succeed Professor Walter Brown as Professor of Mathematics in 1948. He received his B.Sc. degree in mathematics from Sun Yat-Sen University [(also known as Zhongshan University)] in 1935 and was selected in 1938 as a Sino-British Boxer Indemnity Scholar to pursue doctoral study in Britain, where he wrote his thesis on generalized helices in Riemannian space under Professor Evan Davis of University of London and received his Ph.D in 1940. He spent several years in the US at the Institute for Advanced Study in Princeton, MIT and University of Pennsylvania before returning to Sun Yat-Sen University as Professor of Mathematics. He built up the Department of Mathematics at HKU with five members on its teaching staff (including demonstrators) into the best department in the Faculties of Arts and Science, with over twenty members, when I entered the university. On his 90th birthday on 31 May 2003, the Vice-Chancellor of HKU mentioned the exceptional contributions of Professor Wong to HKU and to tertiary education in Hong Kong during his “six decades as a mathematician and educator”. I also sent my heartfelt congratulatory note: “When I look back on my career, I feel extremely fortunate in having several great teachers and mentors, and Professor [Yung-Chow] Wong is one of them.”

In October 1967, I was selected for the Commonwealth Scholarship to pursue doctoral study in Britain. I had also applied to Stanford, Toronto and Columbia, which required the applicants for their Ph.D programs to take the Graduate Record Examination (GRE). Now that I already got the Commonwealth Scholarship, I did not have much incentive to take the GRE. After finding out that Columbia did not require the GRE for overseas applicants, I just applied to Columbia where I also had former classmates from HKU Math studying for their Ph.D.s. That was why I left Hong Kong in September 1968 to study at Columbia.

**I** Why did you apply to the Department of Mathematical Statistics instead of the Department of Mathematics at Columbia, and why did you go to the US instead of the UK?

**L** To answer this question, I want to follow up with subsequent developments in Hong Kong and at HKU in the year of the leftist riots. The violent clashes

between the leftist rioters and the police peaked in the summer. The British Hong Kong Government imposed emergency measures to quell the unrest. Leftist newspapers and schools were shut down; leftist rioters retaliated by planting bombs throughout the city. On August 24, a popular anti-leftist radio commentator Lam Bun was burned to death in his car when he drove to work with his cousin. There was widespread outcry against the violence, which began to taper off. Therefore, when I reported to work at HKU in September, the leftist riots and demonstrations subsided and normal life gradually returned to Hong Kong. I also got another offer from a former teacher to move to his new Department of Statistics.

The Faculty of Social Sciences at HKU was established in September 1967 and consisted of the Departments of Economics, Geography, Psychology, and Sociology that had belonged to the Faculty of Arts, together with two new Departments – Statistics and Social Work. (The candidate for the next governor of Hong Kong, Carrie Lam <sup>[1]</sup> received her bachelor’s degree from the Department of Social Work at HKU about ten years after I received mine from the Department of Mathematics.)

The Department of Statistics basically moved the faculty members (including demonstrators) teaching statistics courses in the Department of Mathematics to the Faculty of Social Sciences. E. R. Chang, Head of the Department of Statistics was a Reader in the Department of Mathematics and had received his master’s degree from Yale. Although he was of Chinese ancestry, he could neither speak nor write Chinese. He had only taught me in my first-year statistics course but liked me, and explained to me the advantages of moving to his department as a demonstrator. He would recommend me for a Commonwealth Scholarship to study for a higher degree in statistics in Britain so that I could be promoted to Lecturer upon my return in a couple of years. He told me that Mathematics had so many talented students and junior staff that it would be hard to move up the academic ladder. I took his offer of going overseas to study for a higher degree in statistics and then returning to his department as Lecturer, but still remained in the Department of Mathematics as Professor Wong’s assistant. That was why I pursued my doctoral study in statistics instead of mathematics. Although I was definitely interested in statistics and there was a position for me in the Department of Statistics at HKU, I knew much more pure mathematics than statistics in those days.

Concerning why I went to Columbia instead of going to the UK with a Commonwealth Scholarship, a simple answer is to cite the economic principle of hedging with options. Although I didn’t know that principle in those days, I was an economist at heart. The position at HKU only required a higher degree in statistics. If I went to Columbia, I had more options to apply for positions in the US besides that of returning to HKU. On the other hand, taking the Commonwealth Scholarship had no other option than returning to Hong Kong. Many years later,

when I had to learn and teach option (pricing) theory in finance, I asked myself the price of taking the Columbia option, but this is irrelevant to your question. <sup>[2]</sup>

**I** After your Ph.D, you stayed on the faculty at Columbia from 1971 to 1987. Then you moved to Stanford. Please tell us why you stayed at Columbia for 16 years and then joined Stanford, and some highlights of your work at both universities.

**L** Well, actually these questions were already asked by three former Ph.D students and my answers to them were published in "Conversations with Tze Leung Lai", *ICSA (International Chinese Statistical Association) Bulletin* January 2016, pp. 29-40. <sup>[3]</sup> Therefore let's move on to your next question.

**I** The late Peter Hall (1951-2016) once said that statistics is not its own master, unlike pure mathematics which is free to choose its own problems to solve. [ <https://ims.nus.edu.sg/imprints/imprints-28-2016.pdf#page=12> ]

Is there such as a thing as "pure" statistics which is free to chart its own course of development without being overly directed by practical problems and applications?

**L** Concerning Peter Hall's career, he started to study physics at the University of Sydney to follow the footsteps of his mother, who was a pioneer in radiophysics and solar radio astronomy. However, he did not like the teaching there and switched to mathematics after his first year. He then studied for the M.S. degree in mathematics at the Australian National University (ANU), where he worked in probability under Pat Moran [(1917-1988)], and later Chris Heyde [(1939-2008)]. Then he went to Oxford to pursue his doctoral study and wrote his Ph.D thesis on limit theorems for stochastic processes and sums of random variables under the supervision of Sir John Kingman, who had visited ANU and first met Peter in 1974. After receiving his Ph.D from Oxford, Peter returned to Australia where he spent his academic career at ANU and later at the University of Melbourne, while also holding visiting and fractional appointments at many other universities in different parts of the world. His research exemplifies "charting its own course of development" and being "its own master", yet finding important real-world applications such as his work on fractals and his papers on the bootstrap method in the *Breakthroughs in Statistics* collection. Unlike me, Peter had planned to be an academic mathematician dating back to his undergraduate days at the University of Sydney.

I want to conclude with a related story. Peter's wife Jeannie received her B.A. degree from HKU about five years after mine, joined the civil service as an Administrative Officer and was sent by the British Hong Kong government to study at Oxford, where she met Peter. In one of the parties with Peter who was visiting HKU, I told her that she had taken my dream job in civil service and explained how I got another dream job as an academic like her

husband. In those years, there was the famous movie "The Accidental Tourist" that was nominated for four Academy Awards, and won one, in the 1988 Oscars. Jeannie said: "So you are the accidental mathematician. <sup>[4]</sup>" [Laughs] Her cute remark also addresses your question to the point. Yes, as an accidental statistician, I do not have the luxury to choose my own problems, especially when I am working in a large team with other "masters" charting the course of development of an interdisciplinary project. Instead I try to learn from my collaborators with different backgrounds across different disciplines and also keep a group of talented students from different schools and departments working on the statistical or data analytic aspects of the projects. Examples can be found in the aforementioned ICSA article "Conversations with Tze Leung Lai".

## Part II. The Interdisciplinary Statistician in Academia

**I** Your faculty appointments at Stanford University are in statistics, biomedical data science, and computational & mathematical engineering, and you are also the Director of the Financial and Risk Modeling Institute, Co-director of the Center for Innovative Study Design, and also a core member of several centers and institutes at the Stanford University Medical School. How do your inter-disciplinary appointments work at Stanford, particularly in terms of your teaching and research?

**L** First I want to point out that these interdisciplinary appointments expanded in stages over the years during the past 32 years that I had spent at Stanford. When I first moved to Stanford, my appointment was in the Department of Statistics, one of the 23 departments of the School of Humanities and Sciences. My teaching load was exclusively in statistics, ranging from undergraduate service courses to advanced Ph.D-level courses. In a Ph.D-level course that I taught in the fall quarter of 1988, I chose the topic of multi-armed bandits and stochastic control to organize my past research at Columbia into an advanced course and to attract potential Ph.D advisees. In the audience was Lewis Sheiner, a visiting professor in the School of Medicine who was spending his sabbatical leave from the University of California in San Francisco (UCSF), one of the premier medical schools of the University of California (UC) system. Lewis introduced himself after the first class and told me about his work in population PK/PD (pharmacokinetics/pharmacodynamics) and his intuition about how stochastic control ideas could be used in this work and in other areas that he was working with the Department of Medical Informatics (now renamed Biomedical Informatics). Also in the audience was Ray Zhu, a Ph.D student in Statistics who later became my first Ph.D student from Stanford and with whom I have been collaborating intermittently to this day. Lewis, a distinguished clinical pharmacologist, later introduced me to the chair Edward Shortliffe of Medical Informatics

**“ HE [PHILIP LAVORI] HAD EXTENSIVE EXPERIENCE IN RUNNING LARGE CLINICAL TRIALS IN THE VETERANS ADMINISTRATION COOPERATIVE STUDIES PROGRAM BEFORE CHAIRING HRP, AND WAS A PIONEER IN SEQUENTIAL MULTIPLE ASSIGNMENT RANDOMIZED TRIALS – AN IMPORTANT TOPIC IN THIS IMS PROGRAM. ”**

and to Mark Musen, an assistant professor who was Shortliffe’s former student, about an automatic ventilator for emergency hospital care of patients with severe respiratory diseases. Although I did not know it at that time, this was a precursor of today’s AI (artificial intelligence) in medicine. I brought Ray Zhu, who expressed interest in working with me on research related to my course, to meetings concerning the development of the automatic ventilator, and Ray began to know Lewis well through those meetings.

Lewis returned to UCSF after his sabbatical, Shortliffe subsequently left Stanford for Columbia and Musen succeeded him and quickly rose to prominence, while Ray joined the pharmaceutical company Schering-Plough as biostatistician after receiving his Ph.D degree. Lewis and his colleague Stuart Beal, who had his Ph.D in biostatistics from UCLA before joining UCSF, had developed the NONMEM (Nonlinear Mixed Effects Models) software package which Lewis began to promote to pharmaceutical companies by giving professional courses in different cities. Ray took such a course in Piscataway, New Jersey and got reconnected with Lewis. He then “fell in love” with population PK/PD to such an extent that he left Schering-Plough to join FDA [Food and Drug Administration] and later the company Globomax in Maryland, where he worked with Lewis’s collaborator Tom Ludden. He also got me interested in the subject, which eventually led to my work and related projects beyond PK/PD. Some of these applications can be found in my book *Sequential Experimentation in Clinical Trials: Design and Analysis* with Bartroff and Shih (Springer, 2013), and in the forthcoming book *Data Analytics and Risk Management in Finance and Insurance* with Xing (Chapman & Hall/CRC). Ray later moved back to the pharmaceutical industry, beginning as associate director of biostatistics at Aventis, subsequently as Vice President (VP) at Eisai and currently as VP at Allergan. He consulted me on several occasions about the efficient design of confirmatory clinical trials for regulatory approval of new treatments developed at these companies. My discussions with him first rekindled my interest in efficient group sequential designs of clinical trials that began when I was at Columbia following the early termination of the Beta Blocker Heart Attack Trial in 1981, which led to consultations with pharmaceutical companies and also an NSF [National Science Foundation] university-industry grant, as described in “Conversations with Tze Leung Lai” (*JCSA Bulletin* Jan 2016, p.32). They also led to new research projects in the area of adaptive designs that are summarized in the aforementioned Bartroff-Lai-Shih book. Even more importantly, they led to my work, described below, at Stanford Cancer Center (now Comprehensive Cancer Institute) and at the Center for Innovative Study Design (CISD).<sup>[5]</sup>

In 2004, Stanford’s School of Medicine planned a Cancer Center application to the National Cancer Institute (NCI) and asked me to be interim director of the Biostatistics Shared Resource in the application, based on my publications on innovative clinical trial designs summarized in the preceding paragraph. After receiving

the Cancer Center award, Philip Lavori was recruited by the School of Medicine to be Director of the Biostatistics Shared Resource and Chair of the Department of Health Research and Policy (HRP), which consisted of biostatistics, epidemiology, and health policy. Phil asked me to stay on as Co-director and to join HRP as courtesy faculty; “courtesy” appointment at Stanford means that my salary comes from my dean, whereas a “joint appointment” would mean that the salary is split between the two deans. Working with Phil in the past 14 years has greatly advanced my research in clinical trial design and analysis. He had extensive experience in running large clinical trials in the Veterans Administration Cooperative Studies Program before chairing HRP, and was a pioneer in sequential multiple assignment randomized trials – an important topic in this IMS program. Our close collaboration not only resulted in a very favourable review of the Cancer Center by NCI [National Cancer Institute] that granted the “comprehensive” status to the Center in 2016, but also to the establishment of CISD in 2009. In 2016, the Dean of the School of Medicine moved the faculty in Biostatistics out of HRP to form a new Department of Biomedical Data Science (BDS) that also consisted of certain faculty members from Biomedical Informatics and Genetics, hence I became a courtesy faculty member of the new department. Ying Lu, who succeeded Phil in the Veterans Administration Cooperative Studies Program, moved over to BDS as Professor and also joined CISD as Co-director. Since then, CISD has enough manpower to expand its activities and has been growing quickly, especially after FDA established the UCSF-Stanford Center of Excellence in Regulatory Science and Innovation (CERSI).<sup>[6]</sup> My recent book *Medical Product Safety Evaluation: Biological Models and Statistical Methods* with Jie Chen and Joseph Heyse and my forthcoming book *Real World Data and Evidence: An Interdisciplinary Approach and Applications to Precision Medicine and Healthcare* with Richard Baumgartner and Jie Chen represent some of the “priority areas, based on FDA’s current unmet regulatory science needs” for CERSIs, and can be used for “regulatory science-related training, workshops, and seminars.” Both books are published by Chapman & Hall/CRC. Jie, Joe and Richard are all from Merck, which is an Industry Affiliate of CISD, and I have been collaborating with Jie and Joe since 2009 after their first visit to Stanford. Other pharmaceutical, biotech and healthcare companies have also joined the

Industry Affiliates Program of CISD and collaborated with the core and extended faculty members of the Center. CISD is only one of the centers and institutes in the School of Medicine. I have also joined some centers as a core member, most recently the Center for Precision Mental Health and Wellness, for which “precision” involves brain imaging and genomics. Moreover, besides the School of Medicine, I am also involved in the School of Engineering through ICME (Institute of Computational & Mathematical Engineering) since 2009 and the Mathematical & Computational Finance Program since 2014. I have also been Director of the Financial and Risk Modeling (FARM) Institute since 2012. How this came about has been described in “Conversation with Tze Leung Lai” (*ICSA Bulletin* Jan 2016, pp. 34-35). These interdisciplinary appointments have definitely made my research more interdisciplinary.

Concerning teaching, I still have to teach three courses every year as I am a full-time faculty member of the Department of Statistics. These courses now are all related to the different programs that I run, and I no longer have the luxury of teaching an advanced Ph.D-level course of the kind that I taught in the fall quarter of 1988 to attract Ph.D advisees such as Ray Zhu. On the other hand, because of my interdisciplinary research projects, I have been able to recruit talented students from different schools and departments (including statistics) to work on these projects, which have eventually led to their Ph.D theses under my supervision.

**I** You have mentioned about “a precursor of today’s AI in medicine” at Stanford in the late 1980’s. What is today’s AI in medicine (or in finance) that you have been involved in teaching and research for your interdisciplinary appointments at Stanford?

**L** The major department in AI research and teaching at Stanford is Computer Science (CS), which has AI, CS theory, computer systems, graphics and human-computer interaction, database and network/graph analysis as its five core research areas. CS theory includes complexity theory, cryptography and algorithms, whereas AI includes machine learning, computer vision, robotics, natural language processing and computational biology. AI, also called machine intelligence, is intelligence demonstrated by machines, as opposed to natural intelligence displayed by humans and animals. Other departments and schools are also involved in many of these topics in AI. For example, statistics has introduced many innovations in machine learning. Electrical engineering, mechanical engineering, and aeronautics & astronautics have been involved in robotic navigation and “driverless” cars and spacecrafts; and radiology and biomedical informatics have major advances in computer vision for medical imaging. I have recently developed a new joint course “Deep Learning and AI with Applications to Medical Imaging and Real-World Evidence” with Biomedical Informatics, and another new course “Neural and Statistical Sciences in Artificial Intelligence”. The latter course discusses the interactions between machine intelligence and natural intelligence and describes recent

developments that advance both types of intelligence through such interactions. I also have Ph.D students from statistics, CS and ICME working on related research projects and helping us to develop and teach these courses. AI has become a pillar of FinTech (Financial Technology); the ABCD of FinTech are Artificial intelligence, Blockchain, Cloud computing and big Data. “Blockchain” is another CS topic that is related to cryptography, and so is cloud computing. Big data pertain to Statistics. I have recently been working with some colleagues at FARM and my Ph.D students on FinTech and RegTech (regulatory technology).

## Notes by T.L. Lai

<sup>[1]</sup> Election for the 4th governor of Hong Kong, SAR, took place on 26 March 2017 and Carrie Lam won the three-way election with 777 of the 1194 votes of the Election Committee. She joined civil service as an Administrative Officer and was sent by the British Hong Kong Government to study at Cambridge University, where she met her husband [Siu-Por Lam] who was working on his Ph.D thesis on algebraic topology under Frank Adams.

<sup>[2]</sup> Of greater interest to readers at NUS is that E.R. Chang left HKU in 1968 for the University of Southampton, and the Faculty of Social Sciences advertised the opening for the head of its Department of Statistics. Professor Saw Swee Hock of the University of Malaya in Singapore became the founding Professor of Statistics at HKU in 1969. He received his BA and MA from the University of Malaya in Singapore, and his Ph.D in Statistics from the London School of Economics in 1963. In 1971 he returned to Singapore, which became an independent republic on August 9, 1965, as the first chairman of the National Commission of Statistics. He joined the University of Singapore (formerly University of Malaya in Singapore, and later National University of Singapore since 1980) as Professor of Statistics in 1975. He is also well known for his philanthropy, and was named one of the 48 Heroes of Philanthropy in the Asia-Pacific Region by Forbes Asia Magazine in 2014. His largest donation was in 2011 for the establishment of the Saw Swee Hock School of Public Health at NUS.

<sup>[3]</sup> <http://icsaimage.files.wordpress.com/2016/05/icsabulletin16jan1.pdf>

<sup>[4]</sup> Actually “statistician”, to be more precise.

<sup>[5]</sup> <http://med.stanford.edu/cisd.html>

<sup>[6]</sup> There are currently four such centers: University of Maryland, Johns Hopkins, UCSF-Stanford, and Yale-Mayo Clinic. They are “collaborations between FDA and academic institutions to advance regulatory science through innovative research, training, and scientific exchanges” because “evolving areas of science are promising new approaches to improving our health while demanding new ways to evaluate the safety and effectiveness of the products FDA regulates.”