

PROFILES IN FORENSIC TOXICOLOGY

Professor Kurt M. Dubowski (1921-2017)

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Few if any forensic toxicologists are as closely associated with their particular area of research and expertise as Professor Kurt M. Dubowski (KMD), who died on 23rd October 2017 just one month shy of his 96th birthday. His name is intimately linked with the science and practice of blood- and breath-alcohol testing. Dr. Dubowski was one of the founding members of TIAFT and when the 50th Annual Meeting was held in Hamamatsu in 2012, he was elected an honorary member of our organization. In a scientific career spanning nearly seven decades, KMD made significant contributions to clinical chemistry and laboratory medicine as well as forensic science and toxicology. Kurt is especially remembered for his work on the analysis and interpretation of ethanol concentrations in biological fluids and the use of this information as evidence for prosecuting traffic offenders. KMD's qualities as a visionary leader, an organizer and a dedicated scientist are evidenced by the plethora of honors, awards and commendations that came his way over the years. He served as President of the American Academy of Forensic Sciences (AAFS), President of the American Association for Clinical Chemistry (AACC) and was the founding President of the American Board of Forensic Toxicology (ABFT). KMD's name appears as author or co-author of 204 publications, and on the vast majority of these works he was sole or first author, which testifies to his standing as a consummate scientist and researcher.

Introduction

With the death of Professor Kurt M. Dubowski, AB, MSc, PhD, LLD (h.c.), F-ABFT, D-ABCC, just four weeks before his 96th birthday, the forensic science community and the field of forensic toxicology, has lost a devoted and accomplished practitioner. KMD was especially active in research on the forensic toxicology of alcohol, particularly development and evaluation of methods for the determination of ethanol in biological specimens. In short, he was a trailblazer in the science and practice of blood- and breath-alcohol testing and applications in traffic-law enforcement. He often remarked, in a jovial way, that he would like the name Dubowski to be associated with alcohol testing in the same way that sterling is associated with silver. Looking back at his career, I think we can conclude that his hope and intuition were fully realized.

Dr. Dubowski's academic education began with a bachelor's degree in chemistry (AB) from New York University (NYU) in 1946. He followed this with research for a Masters and Doctoral

degree, both done at Ohio State University in the departments of chemical engineering and medical sciences. The subject for Kurt's MSc thesis, awarded in 1947, was the analysis and identification of arsenic, the king of poisons, in biological fluids and tissue [1] and his PhD degree, awarded in 1949, focused on methods for determination of ethanol in biological specimens [2].

During KMD's student days at NYU one of his chemistry lecturers was the charismatic Dr. Alexander Gettler (1883-1968), who was chief toxicologist in the Office of the Chief Medical Examiner in New York City [3]. As was reported in an earlier TIAFT essay, Dr. Gettler was responsible for training many of the second generation of US forensic toxicologists. He evidently also sparked Dr. Dubowski's interests in the use of chemical methods for investigating unnatural deaths, so in this respect Kurt can also be considered one of the "Gettler Boys" [4].

My first encounter with the name DUBOWSKI came when I was engaged with research for my own PhD degree at the

University of Wales in Cardiff, UK. It was a common practice at the time to spend a lot of time in the university library reading and reviewing the scientific literature. My thesis was concerned with physiological principles and practical application of blood- and breath-alcohol testing in traffic-law enforcement. I soon discovered that one of the “big names” in this field was Professor Kurt Dubowski from the University of Oklahoma, so I created a folder labelled “DUBOWSKI KM” in which I collected copies of all he had written on the subject of forensic alcohol testing.

During the 1970s Dr. Dubowski was working on projects closely related to the work that I was doing for my PhD thesis, namely an investigation of physiological variables and how these influence breath-alcohol concentration. This included studies of the blood-breath ratio of ethanol, the role of breath-temperature, expired volume, breathing pattern, respiratory function etc. In this respect we became competitors, so I followed very closely his publications on these topics [5-7].

During my first trip to North America (September 1974) to attend a conference in Toronto about alcohol, drugs and traffic safety, I took the opportunity to travel around the US. On my agenda was a visit to Dr. Dubowski’s laboratory in Oklahoma City. I spent a morning with him discussing our mutual interests and recent research publications and he showed me the equipment he was using for the analysis of ethanol in blood and breath samples. On leaving his laboratory he congratulated me on the work contained in my thesis and he encouraged me to publish some articles in scientific journals, which was a lot easier said than done. However, I followed Kurt’s advice and eventually managed to publish five original articles based on the results contained in my PhD thesis [8-12].

The format of the British and American PhD thesis is similar and consists of a bound monograph, often running to several hundred pages, containing Summary, Introduction, Methods, Results, Discussion and Conclusion. The raw data from the experimental part of the thesis is often included as an appendix to the monograph. This differs from the convention in some European countries, where a PhD thesis is a compilation of 3-5 published papers. The Dutch and the Scandinavian PhD model consists of reprints of the published articles along with an overall summary, which gives background and motivation for embarking on the research and how the results have advanced knowledge in that particular scientific area or domain.

After our first meeting in 1974 Kurt and I remained friends and colleagues for the next 42 years, although we had some

differences of opinion and did not see eye-to-eye on all aspects of forensic alcohol testing. My last communication with him was just a few weeks before he died when I took the opportunity to send him a pdf reprint of a recent paper I had published entitled “*Postmortem toxicology findings from medicolegal investigations of drug-related deaths among the rich and famous*” [13]. Kurt enjoyed reading this type of scientific article, which combines practical aspects of forensic medicine and toxicology with investigations of unnatural deaths among celebrities.

This forensic toxicology profile reviews the life and work of Professor Kurt M. Dubowski, who pursued two parallel and highly successful careers. One career was in the field of clinical chemistry and laboratory medicine and the other in forensic science and toxicology. Kurt was one of a kind and there will never be another; the mold for this unique individual no longer exists.

Between 1989 and 2015, I met Dr. Dubowski about 2-3 times each year, so I got to know him very well. In this essay I relate some anecdotes and personal reflections to illustrate his personality, idiosyncrasies and also his genius. This tribute mainly focuses on the many contributions he made to research on alcohol and other drugs of abuse. This included the development and validation of new analytical methods, the introduction of quality assurance procedures in forensic toxicology, the pharmacology and pharmacokinetics of ethanol and enforcement of drink-driving laws. Figure 1 shows Dr. Dubowski at different times in his life from a young man of 25 years to an elderly gentleman of 90 years.

Upbringing and educational background

Dr. Dubowski was born in Berlin, Germany on the 21st November 1921 and he lived in that Capital city until 1934. Together with his mother and stepfather (Werner Steinberg MD), they made a wise decision to immigrate to the USA and travelled via Belgium arriving in New York City (NYC) in January 1935. This meant that Kurt was 13 years old when he arrived in a new homeland where he had to learn a new language and adapt to a different culture. All this he achieved with gusto. After living in NYC for the first 6 months the family moved to Baltimore, where Kurt’s physician stepfather obtained an appointment at Johns Hopkins Medical School.

One of Kurt’s childhood heroes was his grandfather (1861-1934), who was a former Prussian soldier [4]. Kurt often told me how he and his grandfather, in the early 1930s, would wander around Berlin on streetcars and they often visited the armory

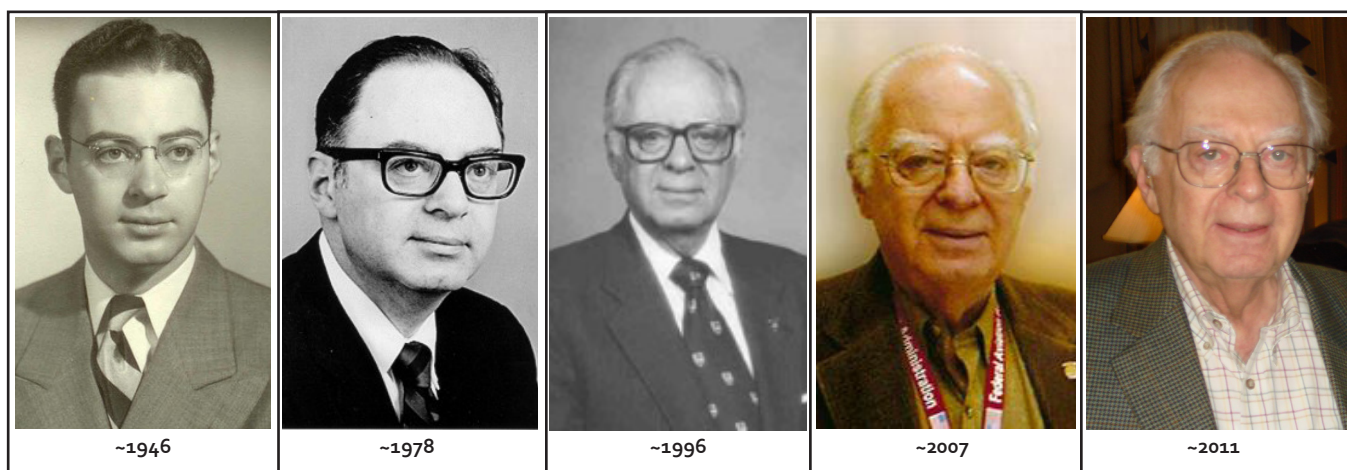


FIGURE 1. PHOTOGRAPHS OF PROFESSOR KURT M DUBOWSKI (1921-2017) THROUGH THE AGES.

to watch the changing of the guard at noon. They especially enjoyed listening to the military bands playing and throughout his life Kurt was a great fan of martial music.

Kurt was determined to speak English without any trace of a German accent, and this he achieved with the help of two dedicated teachers, with whom he kept in contact with for the rest of their lives. Already in junior high school Kurt's nickname was Doc, which might either reflect his early interests in the medical sciences or the fact that his stepfather Werner Steinberg MD, was a practicing physician.

In Irving Sunshine's book *"Was it a poisoning? Forensic toxicologists searching for answers,"* Dr. Dubowski wrote an account of his early career development and he credited Dr. Gettler as being the founding father of forensic toxicology in the USA [4]. The role of Dr. Gettler in training the second generation of forensic toxicology practitioners was reviewed in an earlier TIAFT biographical essay [3]. Kurt's academic studies were interrupted by WWII and he enrolled for service in the armed forces, working mostly as a military intelligence officer in the Asiatic-Pacific (CBI) theaters of war.

Professional appointments and career development

Dr. Dubowski's first professional appointment was in 1950 in Norwalk, Connecticut where he was employed as a Biochemist and Assistant Laboratory Director of the Norwalk Hospital. However, he also held a parallel appointment as forensic scientist and consultant with the Connecticut State Police and Fairfield County Coroner's office.

Throughout his long and distinguished career KMD made it a habit of holding multiple professional appointments simultaneously, often combining laboratory medicine, clinical science and forensic toxicology. Kurt's first senior professional appointment required a move to the Midwest, Des Moines, Iowa. In 1953 he was appointed Director of Chemistry at Iowa Methodist Hospital and Raymond Blank Memorial Hospital for Children. The move to live in Des Moines had some long-term consequences, because Kurt met someone there who would have a profound influence on his life. This person was Natalie Essary, who worked alongside Kurt for 64 years, initially as a scientific assistant, his confidant, loyal collaborator and later his beloved wife. Kurt and Natalie travelled together to many conferences over a period of 50 years and they made a great team. During his sojourn in Des Moines, Kurt also served as State Criminalist for the Iowa Department of Public Safety, and Toxicologist and Chief Deputy Coroner in Polk County and founding director of the Iowa Poison Information center.

Kurt's next appointment was in Gainesville, Florida where he entered academia as Associate Professor at the University of Florida. Besides being responsible for teaching and research he also directed the University of Florida Teaching Hospital and Clinics. True to form, while in Florida, he also consulted with the Poison Information Center and was scientific adviser to the Veterans Administration Hospital, and the Gainesville Police Department. It is mind boggling that one person could combine all these duties effectively, but KMD managed it and he did it with distinction.

Kurt's research and scientific publications began to attract national attention and in 1961, at the age of 40 years, he was offered a Professorship at the University of Oklahoma. This included directorship of the Clinical Chemistry Laboratories at the University Hospital. At the University of Oklahoma he held academic titles of Professor of Biochemistry and Molecular Biology, Professor of Pathology, and Professor of Surgery.

Another appointment during his time in Oklahoma City was as the State Director of Tests for Alcohol and Drug Influence. In this position he exerted a powerful influence over science and practice of DUI-DWI legislation in his home state.

In 1981 Kurt was promoted to "distinguished professor rank" at the University of Oklahoma becoming a George Lynn Cross Distinguished Professor of Medicine. In 1998 he reached emeritus status but stayed on at the university until 2003 (aged 82 y) when he relinquished his positions and rooms at the University and also retired from the State of Oklahoma chemical test board.

Dr. Dubowski was a consummate scientist and the word "retirement" was not in his vocabulary. After leaving the University of Oklahoma he accepted a position (without stipend) as Principal Research Scientist at the Civil Aerospace Medical Institute, Federal Aviation Administration (FAA), Toxicology and Accident Research Laboratory in Oklahoma City. Kurt shared his long experience from clinical and forensic toxicology with specialists charged with investigating airplane crashes. At the FAA Kurt was given a larger office, new furniture and his own reserved parking spot, all of which made him happy. Furthermore, his time at the FAA was scientifically productive and he co-authored 15 joint research articles [14-20]. As a mark of respect and appreciation, the FAA named their new Bioaeronautical Sciences Research Laboratory conference room after Dr. Dubowski.

Scientific organizations AACC, AAFS, ABFT and more

Dr. Dubowski was the last surviving founding member of AAFS and he supported this organization in various capacities with great distinction. At the 50th anniversary meeting in San Francisco in 1998, there were six charter members present and at the banquet Kurt made a toast of appreciation for what had been accomplishments over the past half century [21]. Figure 2 shows a photograph of Kurt standing alongside his then assistant and later his wife Natalie Essary on that auspicious occasion.

Kurt was a founding member of the Toxicology Section of AAFS and served as its Secretary in 1958-60, he chaired the section in 1960-61, and was the Program Chair in 1967-68. Furthermore, he was a member of the Executive Committee of AAFS from 1966 until 1969, and belonged to the editorial board of *Journal of Forensic Sciences* from 1956 until his passing. The high point in Kurt's association with AAFS was when he was elected its 29th President in 1978-79. He also served on the Forensic Sciences Foundation Board of Trustees from 1976 through 1983. He was toxicology section representative on the Board of Directors of AAFS, and in this capacity he was pivotal in introducing a requirement for academic qualifications to become a member of the Toxicology Section. Furthermore, he developed the first laboratory proficiency testing program in forensic toxicology and a Registry of Human Toxicology where postmortem drug concentrations were compiled. Kurt also initiated the establishment of AAFS Section Awards and he chaired the Committee on Certification for forensic practitioners in 1974-75.

Another of Dr. Dubowski's activities and interests was traffic safety research and the fight against impaired driving. In this connection he attended many meetings of the International Council on Alcohol Drugs and Traffic Safety (ICADTS), starting with the 2nd conference in Toronto in 1953 and ending with the 18th meeting in Seattle, Washington in 2007, a span of 54 years. In the early years of ICADTS considerable attention was devoted to development and evaluation of analytical methods

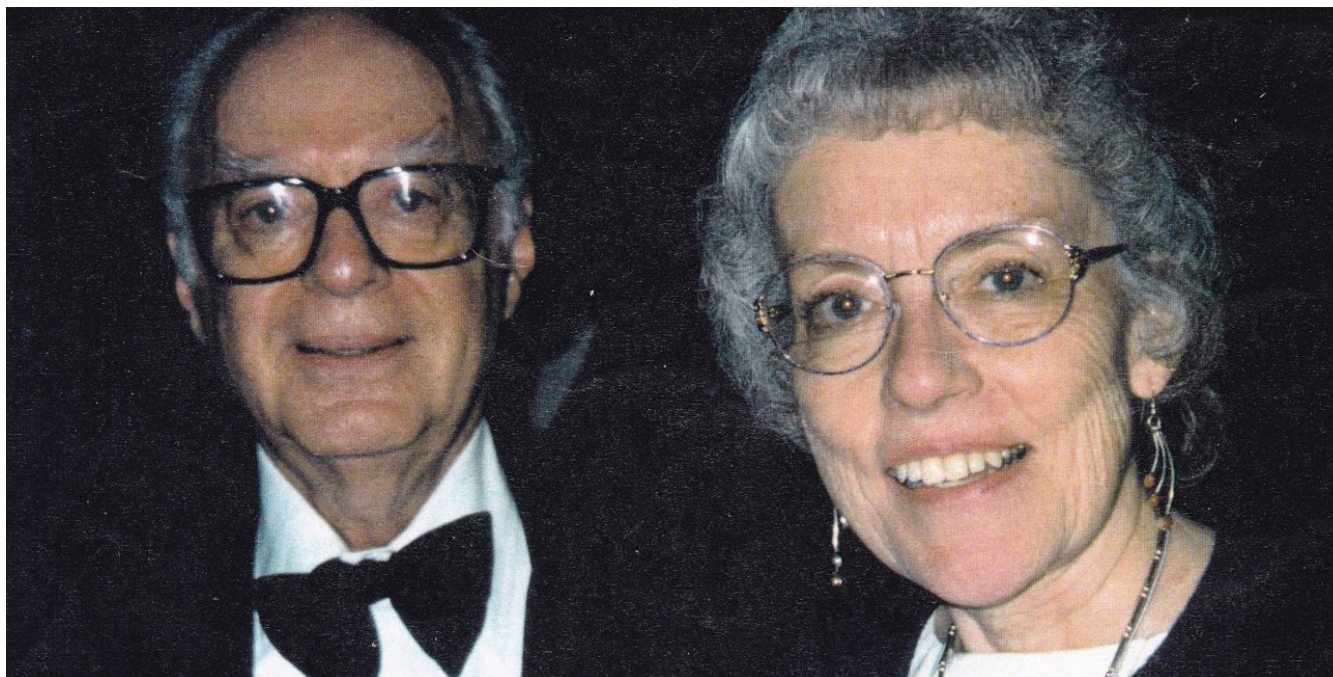


FIGURE 2. PROFESSOR KURT M DUBOWSKI AND NATALIE ESSARY ON THE OCCASION OF THE 50TH ANNIVERSARY MEETING OF THE AMERICAN ACADEMY OF FORENSIC SCIENCES HELD IN SAN FRANCISCO, FEBRUARY 1998.

for measuring ethanol in biological specimens. Accordingly, Kurt's early contribution to this field, including his PhD thesis from 1949, made him a star attraction and he was several times invited to give plenary lectures on these topics. He rose to the rank of vice president of ICADTS and also served as secretary of the awards committee for many years. For those TIAFT members who might want to learn more about the history of alcohol, drugs and driving, I can recommend the ICADTS website (www.icadtsinternational.com), which contains digitalized versions of all published proceedings from previous conferences. These are freely available to search on-line and represent a wealth of information about the history of alcohol, drugs and traffic safety and research efforts and legislation to combat driving under the influence of alcohol and other psychoactive drugs.

The American Association for Clinical Chemistry (AACC) is another scientific society that occupied much of Dr. Dubowski's time and energy over many years. He joined AACC in 1950 and his talents as an organizer and visionary leader were soon recognized and utilized. For example, he chaired or was a member of numerous AACC committees and task forces, including one that led to revision of the code of ethics (1990). He quickly established himself as a "wunderkind" in this organization and his presence was felt at the annual scientific meetings. Among other things, Dr. Dubowski served three terms on the board of directors, he was appointed secretary and then elected president of AACC in 1985. For many years KMD served on the editorial board for the journal CLINICAL CHEMISTRY, which I can verify because he peer-reviewed many articles that I submitted for publication in the 1980s-1990s when Stanton King (1922-2001) and David Bruns (born 1941) were editors-in-chief. AACC honored Dr. Dubowski in 1973 with the AACC Award for Outstanding Contributions through Service to the Profession of Clinical Chemistry, and again in 1996 with the AACC Outstanding Lifetime Achievement Award in Clinical Chemistry and Laboratory Medicine.

Another scientific organization close to Kurt's heart was the International Association for Chemical Testing (IACT), which specializes in the analysis and interpretation of alcohol and drug concentrations in biological specimens. Kurt belonged to the

IACT executive board for many years, and was deeply involved in all aspects of IACT helping to plan future meetings and other matters. He also attended many IACT meetings and gave plenary lectures and seminars as part of the scientific program. On Kurt's initiative and endowment, IACT established the Kurt M. Dubowski award to honor members of that organization for their career-long contributions to knowledge about forensic blood- and breath-alcohol analysis.

For more than 50 years Kurt was a dedicated member of the US National Safety Council, Committee on Alcohol and other Drugs (NSC-CAOD) and chaired that organization for the period 1969-1971. Kurt had a dominant influence at meetings of the NSC-CAOD and he belonged to various sub-committees charged with reviewing the literature on alcohol and road-traffic crashes and promulgating opinions and recommendations about ways to combat drunken driving. Among other things, he drafted resolutions, such as one about acceptable scientific practices for use of evidential breath-alcohol analyzers, the risk of encountering interfering substances in breath, and the need for duplicate determinations, etc. His many contributions to NSC-CAOD were recognized in 1992 when Kurt received the Robert F. Borkenstein award. Thereafter he played an active role as chair of the committee that reviewed the qualifications and contributions of people nominated to receive this same award.

Scientific publications

Dr. Dubowski's bibliography lists 204 scientific works comprising original articles, reviews, book chapters, government reports, editorials, letters to the editor and conference abstracts. His research production began with his Masters and Doctoral dissertations, which were accepted by Ohio State University in 1947 and 1949, respectively. An article about the use of beta-blocker drugs by pilots was published in the January 2018 issue of *Journal of Analytical Toxicology* [20] with KMD as a co-author, which makes a time span of 71 years between his first and last scientific paper, which probably sets a record for forensic toxicologists.

Browsing through Dr. Dubowski's list of publications, one notices that his name appears as solo author or first author on the vast majority of the items listed, which makes it obvious to whom the credit and responsibility belong. Some of the papers penned by Dr. Dubowski are considered classics of the literature pertaining to forensic blood- and breath-alcohol testing. About 21 articles listed in Kurt's CV include Natalie Essary's name as a co-author, which is testimony to her important contributions to the work reported and to KMD's career as a whole [22-28].

The most prominent key words among KMD's publications, without any doubt, are alcohol, analysis, ethanol, blood and breath. However, important works can be identified dealing with development and validation of new methods of analysis, quality assurance aspects, disposition and fate of ethanol in the body (pharmacokinetics) and impairment resulting from excessive drinking in relation to a person's BAC (pharmacodynamics).

After retirement from the University of Oklahoma, KMD was appointed Principal Research Scientist at the FAA in Oklahoma City and 15 articles were subsequently published by this organization with his name as a co-author. These dealt with various topics in aviation toxicology including drug-use by commercial airline pilots [17], analysis and interpretation of carbon monoxide and carboxyhemoglobin in victims of plane crashes [14]. Other papers dealt with validity of urine testing for alcohol and drugs and identification of dilute specimens via creatinine analysis [18], evidence of post-mortem synthesis of ethanol by use of the serotonin metabolite 5-hydroxytryptophol (5-HTOL) as a biomarker [15], and the prevalence and occurrence of THC in post-mortem blood from victims of aviation accidents [16].

From KMD's hundreds of published papers and reports several have become "citation classics" because of the frequency of being cited in papers penned by other scientists. The most highly cited article was published in 1962 and described a method for the determination of glucose content of blood, arguably the most common clinical laboratory assay at the time. The article was entitled "*An o-toluidine method for body fluid glucose determination*" and appeared in CLINICAL CHEMISTRY reaching over 600 citations by January 2018 [29]. In 2008 Kurt was asked to write a commentary about this "citation classic" to explain the principles of the method and why he felt the paper had been so highly cited [30].

Patrick Harding [31] wrote a memorial to Dr. Dubowski and identified many of his scientific accomplishments in alcohol and drug testing and these are summarized below along with supporting literature citations:

- KMD devised a chart showing typical signs and symptoms of alcohol influence in relation to a person's blood-alcohol concentration. The first such Alcohol Influence Chart was published in 1957 [32] and the most recent version dates from 2012 [33]. This chart is widely distributed and used for scientific and legal purposes.
- KMD together with his mentor and colleague Morton Mason [34] suggested that breath alcohol concentrations (BrAC) should be reported directly in units of g/210 L and not converted to a presumed BAC [35]. This notion was later adopted by the National Safety Council Committee on Alcohol and Other Drugs (NSC/CAOD) and incorporated into the Uniform Vehicle Code. The National Highway Traffic Safety Administration (NHTSA) also adopted this practice.
- As state director of tests of intoxication in Oklahoma since 1969, Dr. Dubowski received NHTSA grant funding

to develop program policies and practices that served as a model for many other states.

- KMD always stressed the importance of making all determinations of ethanol concentration in duplicate when results were used for legal purposes. This was suggested already in 1960 [36] and was later adopted by law enforcement agencies in Canada and the US National Safety Council in 1986 [37].
- KMD proposed in 1985 that the National Bureau of Standards (now the National Institute of Standards and Technology) should prepare and supply the ethanol solutions needed for calibration of instruments used for forensic blood- and breath-alcohol analysis and accuracy specifications should be stated.
- KMD refined the calibration procedure for evidential breath analyzers and he derived the "Dubowski equation" relating air-water partition ratio of ethanol as a function of equilibrium temperature. This equation became widely accepted and used to calculate the concentration of ethanol in the effluent from a wet-bath simulator device and calibration control of breath analyzers [25].
- KMD documented the principles and practice necessary for use of dry gas alcohol standards, which were later adopted by NHTSA in 1994 [27].
- KMD and others formulated recommendations and rules for Federal workplace drug and alcohol testing, which is now sanctioned for all those involved in safety-sensitive work [38].
- KMD and others drafted federally regulated standards for blood alcohol analysis in clinical chemistry laboratories [39].
- Created a certification program for clinical chemistry and forensic toxicology, such as The American Board of Forensic Toxicology (ABFT), which served as a model for other accreditation bodies in forensic science and legal medicine arenas.
- KMD was a sole author of a highly cited article in the journal Clinical Chemistry published in 1962 and describing a method for blood-glucose determination that has garnered 633 citations as of January 2018 [29].
- KMD was a much admired instructor, spanning a period of 54 years, at the Indiana University Robert F. Borkenstein Course on Alcohol and highway safety. The history and present status of the course was well described by Kurt in a review article [40].
- A career-long involvement in quality assurance (QA) and quality control (QC) applied to forensic alcohol and drug testing.
- Involvement at the highest levels in several professional organizations related to clinical chemistry and forensic science, serving as past President of both AACC and AAFT and founding President of ABFT.

Breath-alcohol analysis

The bulk of Dr. Dubowski's published papers between 1959 and 1996 deal with various aspects of blood- and breath-alcohol testing for clinical and forensic purposes. He was a major supporter of the Borkenstein Breathalyzer instrument and its use to generate evidence for prosecuting traffic offenders. During development of the Breathalyzer in the mid-1950s, Kurt

made useful suggestions to improve its design and practical operation. Throughout his career Kurt was a strong supporter of the Breathalyzer and other breath-alcohol analyzers whenever the results were being challenged in the courts of law.

In an oral interview done by Shirley Ezelle in 2001 [41] on the occasion of Kurt's 80th birthday he was asked "*what do you think is the single greatest advancement that has ever been made in the field of forensic alcohol analysis?*" Without any reservation he answered "*It is undoubtedly Bob Borkenstein's invention of the Breathalyzer® and its deployment and application to traffic law enforcement. A close second is Gottfried Machata's development of gas chromatographic headspace analysis for ethanol in blood and other biological fluids.*"

Kurt's pre-eminence in the field of forensic alcohol testing was apparent early in his career, and was established beyond doubt after publication of a seminal review article co-authored with his long-term friend and mentor Dr. Morton Mason (1902-1985) from Dallas, Texas. Their article appeared in *Journal of Forensic Sciences (JFS)* in 1974 and ran to 31 pages of text that should be compulsory reading for anyone interested in breath-alcohol testing [35]. A closely related article, also co-authored with Mason, appeared in *CLINICAL CHEMISTRY* two years earlier [42]. Both papers advocated that when breath-alcohol analyzers were used in law enforcement the results should be reported as g/210 L breath and that making a conversion to the "estimated" BAC in g% should be abandoned. They also showed that calibration of breath-analyzers with a 2100:1 blood-breath ratio gave results that underestimated the coexisting venous BAC by about 10% on average when comparisons were made during the post-absorptive phase of the blood-alcohol curve. In short, use of the Breathalyzer instrument by traffic police officers gave a certain advantage to a drunk driver compared with determination of ethanol in a sample of venous blood.

Among many wise words and sound advice in the JFS article one finds the statement:

We believe that the conversion of a breath quantity to a blood concentration of ethanol, for forensic purposes, should be abandoned and that the offense of driving while under the influence of alcohol should be statutorily defined in terms of the concentration of ethanol found in the breath in jurisdictions employing breath analysis. The breath sample should be obtained and analyzed only with instruments having capabilities which would require some extension of present federal standards for evidential breath-testing devices.

Kurt put a lot of effort into developing ways to trap samples of breath for later confirmatory analysis at a laboratory. This was necessary because several US states mandated that DUI suspects had the right to request a verification analysis at a private laboratory. This line of research required selection of trapping materials and evaluation of storage stability of ethanol when re-analyzed under various conditions of storage. The materials tested included Tenax, silica gel, molecular sieve, and calcium sulfate [22, 43]. The requirement for trapping a breath sample and providing this to a DUI suspect for later analysis has since been abolished.

The drink-driving statutes in 48 of 50 US states now report threshold concentrations of alcohol for driving as either 0.08 g/210 L breath or 0.08 g% blood, thanks to the concerted efforts and persistence of Dr. Dubowski and others. When European nations introduced evidential breath alcohol analyzers starting in the early 1980s, the prevailing statutory BAC was divided by an assumed blood-breath ratio (BBR) of alcohol to obtain the

corresponding statutory BrAC limits. Unfortunately, there was no international consensus as to what BBR should be used to derive the statutory BrAC. In the UK a blood limit of 80 mg/100 mL was divided by an assumed BBR of 2300:1 to give the statutory BrAC limit of 35 µg/100 mL.

KMD contributed to almost every area of forensic alcohol toxicology starting with a major review of analytical methods for determination of ethanol in blood and breath. This article was published in *JAMA* in 1959 and occupied 36 pages in that prestigious journal, which set a record at the time. Natalie Essary told me that official reprints of that article were the most expensive they had ever purchased. Buying reprints is now a part of publication history, but before the internet and pdf files existed it was a common practice to order a few hundred reprints when the proofs of an article were returned to the publisher. The cost of the reprints depended on the journal where the work was published, the number of printed pages, whether there was a graph or photo in color, the number of reprints purchased and whether these were with or without covers.

Another aspect of forensic breath-alcohol testing spearheaded by Dubowski and Essary was calibration control of accuracy and the quality assurance if the results were going to be used to prosecute traffic offenders, especially with a concentration per se statute operating in most US states. In this connection they investigated the performance of wet-bath simulators [25, 26] and dry-gas calibration standards [27]. Quality assurance and quality control of the results of forensic alcohol testing were very close to Kurt's heart and this is reflected in his lectures and publications.

For many years KMD was much involved with laboratory proficiency programs, such as those offered by the College of American Pathologists (CAP). Since then inter-laboratory proficiency tests have expanded greatly and constitute an important element in laboratory accreditation. In this respect KMD was before his time [44]. Furthermore, he formulated and enumerated the acceptable practices and requirements when breath alcohol instruments were used for evidential purposes, later endorsed by the US National Safety Council and other organizations [45].

KMD's breath-alcohol research involved extensive studies on the scientific basis and actual performance of breath-alcohol simulators, compressed (dry-gas) vapor-alcohol control materials, human respiratory parameters, duplicate breath sampling, specificity of breath-alcohol analyzers, alcohol pharmacokinetics, remote breath-alcohol sampling and analysis, quality assurance in forensic toxicology, breath and blood-alcohol measurements, gas chromatographic headspace analysis for volatile organic substances, studies on the blood/breath alcohol relationship etc.

Many other papers in Kurt's bibliography testify to his long-standing interest in the principles and practice of breath-alcohol testing. He investigated and wrote about analytical specificity of various instruments and the response to interfering substances, especially acetone [23, 24] and other endogenous and exogenous volatiles.

Review articles

Writing a comprehensive review article with a critical appraisal of all the scientific literature on a topic represents a mammoth task. Unfortunately, writing such review articles is not considered especially meritorious when people apply for promotion and/or tenure, which is hard to understand

considering the time and effort involved. Kurt's knowledge of the scientific literature was supreme, which made him a master of writing review articles. The review article published in JAMA and co-authored with Theodore E. Friedemann gave a critical appraisal of analytical methods used to determine ethanol in blood and breath samples [46]. KMD often made periodic updates of the available analytical methodology for clinical and forensic alcohol analysis [47, 48]. A good example of this is given by a US Government sponsored report about the technology used for breath-alcohol analysis [49, 50].

Some of Dr. Dubowski's articles are so comprehensive that they could easily have been published in book format. One example that comes to mind is a government report from 1977 that dealt with the development, refinement and validation of a gas chromatographic (GC) headspace (HS) method for ethanol determination in biological fluids that ran to 112 pages [51]. HS-GC became the acknowledged "gold standard" reference method of analysis and was used in clinical and forensic laboratories nationwide for more than 3 decades.

Relationship between BAC and intoxication

Many studies have demonstrated an association between the amounts of alcohol consumed and the severity of intoxication. However, a person's BAC or BrAC can be determined a lot more reliably than the level of intoxication. The clinical signs and symptoms of intoxication in relation to BAC were established early in the history of alcohol research. But perhaps the most widely referenced compilation is credited to Dr. Dubowski. The first edition of his so-called alcohol influence chart was published in 1957 [32] and the latest version stems from 2012 [33]. This chart, which was copyrighted by Dr. Dubowski, has been reproduced in many books and manuals dealing with clinical and experimental research on alcohol, and is widely cited in court cases involving alcohol intoxication and drunkenness.

The latest version of the Dubowski table or chart relating a person's BAC with typical signs and symptoms of intoxication is reproduced in table 1. When reading this table it is important to appreciate that much depends on the pattern of drinking, the type of beverage consumed and characteristics of the drinking subjects, including age, gender, time elapsed after drinking and not least habituation to alcohol (tolerance). Rapid drinking on an empty stomach to reach an early occurring peak BAC leads to more pronounced signs and symptoms of drunkenness compared with consumption of the same amount of alcohol over several hours. People who are accustomed to heavy drinking are less influenced compared with novice drinkers. Note that BAC ranges given in the first column of table 1 overlap to some extent.

Expert testimony

Forensic science is the interaction between science and law and administration of justice. When one considers Dr. Dubowski's comprehensive education, training, and experience it is natural that his expertise was in demand in cases involving alcohol and/or drug impairment, such as impaired driving, date-rape and drug overdose deaths. KMD was board certified by the American Board of Clinical Chemistry (ABCC) and the American Board of Forensic Toxicology (ABFT), which made him highly qualified to testify as an expert witness in questions about the concentrations of ethanol and other drugs in biological specimens.

Throughout his career KMD testified in both criminal and civil litigation, although he was predominantly known and hired as a prosecution witness in criminal trials. Kurt was a formidable

expert witness, not only because of his breadth of knowledge in chemistry and medical sciences, but also his ability to make oft complex scientific issues understandable to a judge and jury. He often said that there were people that were smarter than he was, but there were few who were so well-read and well-prepared as he was prior to a trial.

During his career Kurt testified and/or was consulted on several so-called "high-profile" cases, designated as such either because of media attention given to the case, owing to the "celebrity" of the accused or because of the seriousness of the offence e.g. in terms of the number of lives lost in a transportation crash. The outcome of some of the drink-driving trials that Kurt testified in had long term consequences for public policy and established new case law.

State of New Jersey vs Mario Jascalevich.

This was a murder trial and the person charged was Dr. Mario Jascalevich, an Argentina-born surgeon, who became known in the media as Dr. X. In 1976 he was indicted for killing several of his patients by injecting them with the muscle relaxant drug d-tubocurarin. In that case Kurt served as a scientific consultant to the prosecution team, because much of the testimony concerned the use of "novel" analytical methods to determine d-tubocurarin in tissue from exhumed bodies. Questions arose about the extraction and clean-up methods, the stability and degradation of drug during burial, suitability of the analytical methods, such as radioimmunoassay, HPLC and GC-MS. After a long trial (34 weeks) with testimony from many expert witnesses for both sides, Dr. X was acquitted of the murder charges, and the jury deliberated for less than three hours. However, Dr. Jascalevich lost his license to practice medicine in New Jersey and returned to live in his native country of Argentina, where he died from a cerebral hemorrhage aged 57 years.

State of California vs Christian Brando

Kurt often spoke about his involvement in the trial of Christian Brando (1958-2008), who was accused of first-degree murder for shooting his half-sister's boyfriend Dag Drollet (1963-1990). The crime took place at Marlon Brando's home on Mulholland Drive in the Hollywood Hills, Los Angeles in 1990. The police investigation showed that Christian Brando had a blood-alcohol concentration of 0.19 g%. However, the blood sample was taken several hours after the shooting and because of metabolism of ethanol the BAC was probably much higher earlier in the evening when the crime was committed.

Dr. Dubowski calculated that at the time of the shooting the suspect's (Brando) BAC was at least 0.27 g%. He further opined that a heavy drinker might be able to drive and to function at that BAC level, but his thinking, planning, judgment and reasoning abilities would be impaired. Key questions in the run-up to trial included variations in the rate of ethanol elimination from blood, the relationship between BAC and intoxication, development of tolerance as well as a person's ability to form criminal intent at such high BAC. The lead defense lawyer hired by Marlon Brando was Robert Shapiro, who knew of Kurt's special expertise on the subject of alcohol and invited him to join the defense team. Kurt made several trips to Los Angeles to participate in meetings with the lawyers and on one occasion he met with the "godfather" himself (Brando senior).

On the night of the shooting Christian Brando and his half-sister Cheyenne Brando (1970-1995) had eaten dinner at a restaurant before driving back to the Brando compound. Cheyenne, who was pregnant at the time, had given Christian the impression that she had suffered physical abuse from her

TABLE 1. THE LATEST VERSION OF THE DUBOWSKI CHART SHOWING THE RELATIONSHIP BETWEEN VARIOUS STAGES OF ACUTE ALCOHOLIC INFLUENCE AND THE PERSON'S BLOOD-ALCOHOL CONCENTRATION.

BLOOD-ALCOHOL CONCENTRATION grams/100 mL	STAGE OF ALCOHOLIC INFLUENCE	CLINICAL SIGNS AND/OR SYMPTOMS
0.01-0.05	Subclinical	Behavior nearly normal by ordinary observation Influence/effects usually not apparent or obvious Impairment detectable by special tests
0.03-0.12	Euphoria	Mild euphoria, sociability, talkativeness Increased self-confidence; decreased inhibitions Diminished attention, judgment and control Some sensory-motor impairment Slowed information processing Loss of efficiency in critical performance tests
0.09-0.25	Excitement	Emotional instability; loss of critical judgment Impairment of perception, memory and comprehension Decreased sensory response; increased reaction time Reduced visual acuity and peripheral vision and slow glare recovery Sensory-motor in-coordination; impaired balance; slurred speech Vomiting; drowsiness
0.18-0.30	Confusion	Disorientation, mental confusion; vertigo; dysphoria Exaggerated emotional states (fear, rage, grief, etc.) Disturbances of vision (diplopia, etc.) and of perception of color, form, motion, dimensions Increased pain threshold Increased muscular in-coordination; staggering gait; ataxia Memory loss Apathy with progressive lethargy
0.25-0.40	Stupor	General inertia; approaching loss of motor functions Markedly decreased response to stimuli Marked muscular in-coordination; inability to stand or walk Vomiting; incontinence of urine and feces Impaired consciousness; sleep or stupor; deep snoring
0.35-0.50	Coma	Complete un-consciousness; coma; anesthesia Depressed or abolished reflexes Subnormal temperature Impairment/irregularities of circulation and respiration Possible death
Mean, Median=0.36 90%=0.21-0.50	Death	Death from respiratory or cardiac arrest

boyfriend (Dag Drollet). On one of his trips to LA Kurt wanted to be picked up at the airport by Christian Brando (who was then out on bail) and driven to the Brando home using the same route he took on that fateful evening.

Marlon Brando apparently refused to allow Christian to borrow a car, so Kurt hired a car himself and Christian took a taxi to the airport. On the way home from the restaurant, Kurt discovered that Christian had stopped off at a liquor store and purchased more alcohol. This additional alcohol was more consistent with the BAC calculated by Kurt at the time of the shooting. I am not certain whether Kurt actually testified in a jury trial, because the parties reached a plea agreement. Because Christian Brando pleaded guilty to voluntary manslaughter the murder charge was dropped. The judge sentenced Christian to 10 years in a federal prison, although he was released after serving six years. After his release in 1996 he lived a turbulent lifestyle and died of pneumonia in 2008 just 49 years of age.

State of Rhode Island vs Claus von Bülow

In 1982 Claus von Bülow was found guilty of the attempted murder of his wealthy heiress wife Martha "Sunny" von Bülow on two different occasions by injecting her with insulin. Sunny was found in a coma lying on her bathroom floor; she was hypothermic and hypoglycemic and toxicology results were positive for drugs and alcohol. In the first criminal trial Claus (the husband) was sentenced to 30 years imprisonment, but for constitutional reasons the conviction was overturned and a new trial was ordered. In the appeal Claus von Bülow hired the Harvard lawyer and academic Alan Dershowitz to supervise the defense team.

In the second trial, the defense hired eight medical experts, including Dr. Dubowski, who had the required expertise in forensic toxicology and clinical chemistry (diabetes). He opined that Sunny von Bülow's hypoglycemic coma was not necessarily caused by an insulin injection, but might be related to her consumption of alcohol and the medication she was using as well as her poor state of health. The hospital records showed that Sunny's BAC at midday, when she was admitted to the emergency department, was 0.009 g% determined by an enzymatic method. Kurt testified that despite such a low BAC she might have consumed an appreciable amount of alcohol the previous evening. He stated "*the absolute minimum quantity of alcohol that could have been consumed by Mrs. von Bülow prior to her December 1980 coma was between 2.5 and 5.7 ounces of alcohol, or between two and five regular drinks.*"

Sunny von Bülow remained in a permanent vegetative state until she died in 2008 aged 76 y. The von Bülow case received massive publicity and several books were written as well as a Hollywood movie (Reversal of Fortune, 1990), starring Jeremy Irons as Claus von Bülow. An appraisal of the scientific evidence in the case can be found in a book entitled INSULIN MURDERS, written by Vincent Marks and Caroline Richmond. Professor Marks, who is considered an international authority in clinical biochemistry and hypoglycemia appeared as an expert witness for the defense. The jury in the second trial found Claus von Bülow not guilty of attempting to murder his wife [52].

State of New Jersey vs Andrew Downie et al.

The defense and/or prosecution teams in many DUI-DWI cases recruited Kurt as expert witness considering his immense qualifications and own research on the forensic aspects of alcohol. One such case was State of New Jersey vs Andrew Downie et al., which involved extensive scientific litigation and the involvement of many expert witnesses both from the USA

and other nations. These experts were questioned in depth about the scientific foundation for use of the Breathalyzer instrument as an indirect way to estimate a person's BAC and if the results were to the suspect's advantage or disadvantage compared with drawing blood for analysis. In 1989 the New Jersey police used the Breathalyzer instrument to test drunken driver and defined the offence as 0.08 g% BAC obtained by converting a BrAC assuming a 2100:1 blood-breath ratio. The validity of this ratio came under close scrutiny in the Downie case, because the Breathalyzer is designed on the basis of this ratio. The magnitude of biological variation in the BBR was much discussed and debated in the court as was absorptive vs post-absorptive phases of ethanol metabolism, arterio-venous differences in concentration of ethanol, questions related to uncertainty and benefit of the doubt. An important question was whether the Breathalyzer underestimated or overestimated the concentration of alcohol in venous blood.

Many expert witnesses testified in the Downie case, including the author of this article. In its subsequent opinion reviewing the evidentiary hearing and resolving the matter in favor of the State, the New Jersey Supreme Court wrote;

"The trial court found Dr. Dubowski to be the most impressive expert witness. Likewise, prior New Jersey courts have relied on Dr. Dubowski, recognizing him to be a leading authority on the scientific reliability of the Breathalyzer."

Commonwealth of Kentucky vs Larry Mahoney

Another high profile case in which Dr. Dubowski testified was Commonwealth of Kentucky vs. Larry Mahoney, which involved a road-traffic crash in which 27 people, mostly teenagers, died. The school bus they were travelling in was hit by a pickup truck, apparently travelling in the wrong direction on highway 71. The driver of the truck was drunk. The bus burst into flames and passengers were trapped and incinerated and many survivors suffered severe burns and disability. The driver of the pickup truck was badly injured and taken to hospital for emergency treatment. His BAC at time of the crash was back-estimated by Kurt to have been 0.24 g%, more than twice the statutory limit for driving at the time (0.10 g%). Dr. Dubowski was hired as lead scientific expert witness for the State of Kentucky to explain the relationship between BAC and the risk of involvement in a traffic crash. As usual Dr. Dubowski's evidence was presented with confidence in a pedagogic way and Larry Mahoney was found guilty as charged and sentenced to 16 years imprisonment.

State of Alaska vs Joseph Hazelwood - Exxon Valdez

On March 24, 1989, the Exxon Valdez entered Alaska's Prince William Sound, after departing from the Valdez Marine Terminal full of crude oil. At 12:04 am, the ship struck a reef, tearing open the hull and releasing 11 million gallons of oil into the environment. Suspicion arose that the Captain of the oil tanker, Joseph Hazelwood, had been drinking before the ship departed and that he was under the influence of alcohol when the disaster occurred. The coast guard reported that the Captain's breath smelled of an alcoholic beverage. Blood and urine specimens were obtained from Captain Hazelwood 10½ h after the tanker ran aground and results of analysis showed 0.061 g% in blood and 0.094 g% in urine. Despite these relatively high concentrations so many hours after the disaster a state jury acquitted the Captain of operating the ship under the influence of alcohol.

A forensic toxicologist Richard Prouty (1931-2008) testified as an expert witness for the prosecution in the state trial. However, questions arose about chain of custody of the specimens and

TABLE 2. LIST OF DR. DUBOWSKI'S MAJOR PROFESSIONAL HONORS AND AWARDS IN CHRONOLOGICAL ORDER.

YEAR	TYPE OF AWARD AND THE ORGANIZATION CONFERRING THE DISTINCTION
1973	Award for outstanding contribution to service of the profession of clinical chemistry, American Academy for Clinical Chemistry (AACC).
1980	Widmark Laureate, International Council on Alcohol, Drugs and Traffic Safety (ICADTS).
1981	George Lynn Cross Distinguished Professor of Medicine and Chair, University of Oklahoma.
1983	Rolla Harger Award, first recipient of this award, conferred by the American Academy of Forensic Sciences (AAFS) Toxicology Section.
1984	Honorary Doctor of Laws from Capital University.
1986	Distinguished Service Award, (inaugural), American Board of Forensic Toxicology (ABFT).
1991	Designated as a Distinguished Fellow of the American Academy of Forensic Sciences (AAFS).
1992	Robert F. Borkenstein Award, US National Safety Council, Committee on Alcohol and other Drugs (NSC-CAOD).
1994	Distinguished Alumnus Award, College of Engineering, Ohio State University
1995	Distinguished Service to Safety Award, National Safety Council.
1996	Award for outstanding contributions to Clinical Chemistry, the American Association for Clinical Chemistry (AACC).
1998	George Lynn Cross Distinguished Professor Emeritus of Medicine
2007	Honorary Texas Ranger, proclaimed by the Texas Department of Public Safety.
2011	12th R.B.H. Gradwohl Laureate and R.B.H. Gradwohl Medallion Honoree, American Academy of Forensic Sciences (AAFS).
2012	Elected honorary member of The International Association of Forensic Toxicologists (TIAFT).
2012	Lifetime achievement award, International Association for Chemical Testing (IACT).
2013	Lifetime Achievement Award for Leadership, Ohio State University.
2016	Duane Clark Memorial Award from Oklahoma Highway Safety Office, State of Oklahoma.

purported lack of preservatives in tubes used to draw blood. It also emerged that the samples were not analyzed at a forensic laboratory. In the state trial a lot of litigation concerned rate of ethanol metabolism and the pros and cons of making a back calculation. The mishandling of the blood samples cast doubt on the overall reliability of the toxicology results and Captain Hazelwood was acquitted in a jury trial.

Evidence about Captain Hazelwood's drinking history and habits, including several previous convictions for DUI and the fact his driving license was suspended at the time were not put before the state jury. Furthermore, it emerged that his employer Exxon was aware of the Captain's drinking problem and that he and undergone treatment but relapsed. Forensic evidence at a Federal trial in 1994 included an evaluation of voice and speech patterns from recordings of radio communication between the Captain of the oil tanker and the coast guard. This led to a conclusion that the Captain was under the influence of alcohol at the time the tanker ran aground [53].

In a subsequent civil trial held in federal court the US government hired Dr. Dubowski as their alcohol expert. A jury found that the Exxon Corporation was reckless to have allowed a person with a known history of alcohol abuse to command a supertanker. The jury also concluded that captain Hazelwood, was negligent and reckless when he drank heavily on the afternoon before the Exxon Valdez was scheduled to leave port. Furthermore the Captain was not on the bridge when the tanker ran aground and his capacity to make rational decisions and delegate authority was called into question.

Amtrak/Conrail train crash near Chase Maryland 1987

The crash and derailment of an Amtrak train in 1987 in Maryland resulted in the death of 14 passengers, including the engineer and another member of the crew. A Conrail locomotive failed to stop at a signal and this resulted in the crash with the Amtrak train. The police investigation indicated that some of the crew, including the engineer, tested positive for marijuana metabolite (carboxy-THC). This led to a criminal trial of two of the train crew and imprisonment of one of them.

In 1987 methods for the quantitative analysis and interpretation of THC and its metabolites in blood were fairly primitive. Dr. Dubowski was called to testify in the case and was asked to explain how best to interpret the results. One outcome of the case was that much stricter federal regulations were introduced for use of alcohol and drugs by people engaged in safety sensitive work, including sanctioning of random testing of employees. The scientific and legal aspects of workplace drug and alcohol testing were the subject of a comprehensive review that KMD published in *Nova Law Review* in 1987. This 137 page article entitled "*Drug use testing, scientific perspectives*" [54], could easily have been published as a book.

Honors and awards

Everybody enjoys peer recognition for their accomplishments and contributions to science and KMD was certainly no exception. His illustrious twin careers in clinical chemistry and forensic toxicology led to him receiving almost every award available from several scientific organizations and learned societies. The main ones and the years that they were conferred are listed in Table 2 in chronological order.

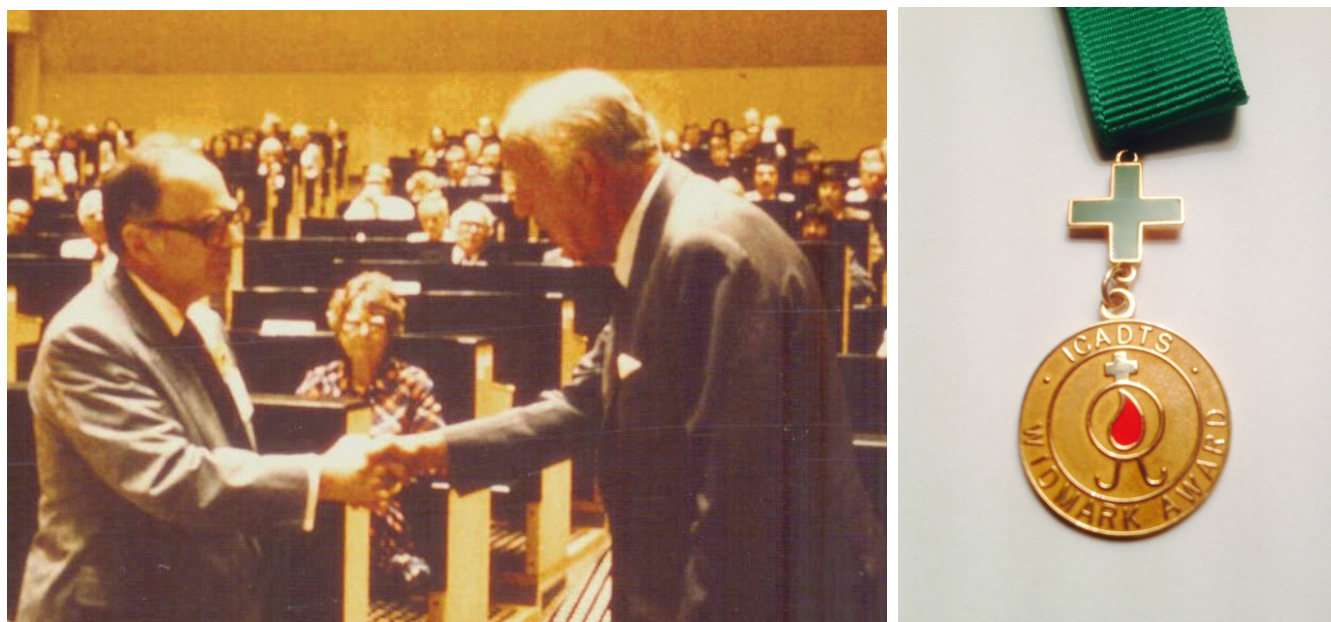


FIGURE 3. DR. DUBOWSKI RECEIVING THE WIDMARK AWARD FROM THE HAND OF H.R.H. PRINCE BERTIL OF SWEDEN WHEN THE 10TH ICADTS CONFERENCE WAS HELD IN STOCKHOLM, JUNE 1980 (LEFT) AND THE ICADTS WIDMARK AWARD MEDALLION (RIGHT).

One of the more unusual awards that KMD received and one that gave him great pleasure, was honorary Texas Ranger. This designation was conferred by the Department of Public Safety in Austin, Texas to commemorate his many contributions to forensic alcohol testing and improvement of traffic safety in that state. One of Kurt's favorite Hollywood movie stars was John Wayne and he often quoted an expression attributed to Wayne, namely "*Speak low and speak slow,*" which is good advice for those who are required to testify in court as an expert witness.

Kurt's knowledge of the forensic alcohol literature was boundless and his German birthright meant he had no problem reading older German literature, including the articles published by Erik MP Widmark of Sweden, who was profiled in an earlier TIAFT bulletin essay [55]. For many years Kurt produced a document called "*Selected references on chemical tests for alcoholic influence*" and this went through periodic updates. I have a copy of the 10th edition, which appeared in 1973, and this contained 31 pages of literature references from English and German scientific journals.

During the 1960s-1970s Kurt was very active as a member of the International Council on Alcohol, Drugs and Traffic Safety (ICADTS). In fact, he was the driving force behind the creation of a WIDMARK AWARD, which is the highest honor this organization can bestow on a member. Kurt designed the award certificate and the accompanying medal that was presented to Professor Rolla Harger when the 4th ICADTS meeting was held at Indiana University, Bloomington in 1965. In a surprise ceremony the award citation was read by Dr. Dubowski, who is a polished speaker and he gave a detailed appraisal of Harger's many contributions to forensic alcohol testing and traffic safety research that motivated his selection as the first Widmark Laureate.

Fifteen years later when the 10th ICADTS meeting was held in Stockholm in 1980, Kurt was recognized with a Widmark Award. I was present at that meeting and witnessed first-hand how pleased he was to be honored in this way, especially when the award was presented by H.R.H. Prince Bertil of Sweden (1912-1997) as shown in figure 3.

Kurt's Widmark Award citation was read by the President of ICADTS at the time Robert F. Borkenstein, himself a Widmark Laureate in 1974. Besides emphasizing Kurt's many contributions to analytical chemistry and forensic toxicology Dr Borkenstein also mentioned the work Kurt had done in jurisprudence leading to drink-driving court decisions and new case law. At the same ICADTS meeting in Stockholm (1980) another TIAFT member was honored with a Widmark Award and this was Professor Gottfried Machata (1925-2012) from Vienna. Machata is perhaps best remembered for his development and application of chromatographic separation methods, such as TLC in forensic toxicology and later headspace gas chromatography for the determination of ethanol and other volatiles in blood samples as reviewed elsewhere [56].

One of Kurt's heroes in forensic toxicology was Professor Rolla Harger from the Department of Pharmacology and Toxicology, University of Indiana and he wrote Harger's obituary after he passed away in 1983 aged 92 y [57]. In 1983 Kurt became the first ever recipient of the Rolla Harger award from the Toxicology Section of AAFS. In February 2011, Kurt received a more prestigious award when he became the 12th RBH Gradwohl Laureate, which is the highest honor that AAFS can bestow on a member. KMD had already achieved AAFS distinguished fellow status in 1991 as well as two awards of merit in 1976 and 1979.

The US National Safety Council Committee on Alcohol and other Drugs conferred upon Kurt its Robert F. Borkenstein Award in 1992 and in 1995 he was recognition for Distinguished Service to Safety by the US National Safety Council.

In 1994 he was made a Distinguished Alumnus of Ohio State University and in 2013 he returned to his Alma Mater to receive a Lifetime Achievement Award for Leadership. The last recognition that Kurt received was from his home state of Oklahoma when in 2016 he was recipient of the Duane Clark Memorial Award for Highway Safety.

Other notable accolades were the American Association for Clinical Chemistry award in 1996 for Outstanding Contributions to Clinical Chemistry and the first ever life-time achievement award created by the International Association for Chemical



FIGURE 4 (LEFT). ROBERT F. BORKENSTEIN (LEFT), THE AUTHOR OF THIS PROFILE (MIDDLE) AND KURT M. DUBOWSKI (RIGHT) DURING AN ALCOHOL TEACHING COURSE AT INDIANA UNIVERSITY AROUND 1990.



FIGURE 5 (RIGHT). KURT M DUBOWSKI AND A.W. JONES SITTING TOGETHER AT A LUNCHEON MEETING FOR MEMBERS OF THE EDITORIAL BOARD OF JOURNAL OF FORENSIC SCIENCES DURING THE ANNUAL MEETING OF AAFS HELD IN ORLANDO, FEBRUARY 2015.

Testing.

As one of the founding members of TIAFT, Dr. Dubowski was elected an honorary member of our organization when the 50th annual meeting was held in Hamamatsu in Japan in 2012. In several e-mails to me Kurt mentioned how much he enjoyed reading the TIAFT bulletin, especially the articles about history of drug discovery that appeared between 2009 and 2013.

All-in-all, I seriously doubt whether the totality of the awards listed in table 2 will ever be matched or surpassed by another forensic science and/or forensic toxicology practitioner.

Personal reflections and reminiscences

From an early stage in my career, Dr. Dubowski became one of my scientific heroes. After our first meeting in September 1974, we remained friends and colleagues until the time of his death in 2017, a period of 43 years. When I visited his laboratory in Oklahoma City in 1974 he had already received a pre-publication copy of my PhD thesis "*Equilibrium partition studies of alcohol in biological fluids*," which was awarded by University of Wales [58]. Dr. Dubowski complimented me about the thesis and considered that I had made some useful contributions to knowledge about the principles and practical application of breath-alcohol analysis.

During my visit to KMD's laboratory I saw that he was using state-of-the-art equipment for blood-alcohol analysis, namely a Perkin-Elmer headspace gas chromatograph (F45) and for breath-alcohol analysis he used an Omicron Intoxilyzer 4011 quantitative infrared analyzer. While sitting in his office I noticed that the walls were covered with photographs of people he admired and the awards and/or certificates he had received up to that time. Everything in his office and laboratory was neat and tidy and well organized, and these traits I later learned were characteristic of him.

We often spoke about writing a joint paper on some aspect of blood- or breath-alcohol analysis, although this project, for various reasons, never came to fruition. Kurt was a perfectionist in everything he did, including writing papers for publication,

and this made it difficult to produce a final manuscript, because he was so careful about the language. The written word is more permanent than the spoken word and information contained in a published paper enters the public domain.

Being one step ahead of Kurt in anything to do with science and/or technology was not easy. For example, I purchased my first digital camera in 1998 a so-called SONY Mavica, which stored the images on a 3.5 inch floppy disk. When I showed the camera to Kurt at one of the Indiana University teaching classes that we both attended he told me that he already owned two such cameras including a more recent model! However, I did manage to beat him once when I used, for the first time, a "green laser" pointer for my presentation during the December alcohol course, whereas Kurt used a conventional "red laser." On the occasion of the May course, Kurt showed up with a "green laser" pointer that looked as if it might burn a hole in the PowerPoint screen – so much for my wimpy green laser pointer!

After my first appearance at the Borkenstein course as a surprise guest (May 1989), Kurt and I met twice annually as members of the teaching faculty on this internationally renowned course of instruction on alcohol and highway safety [40]. Figure 4 is a photograph taken at one of my first appearances at the alcohol course ~1990, showing Dr. RF Borkenstein standing beside Dr. AW Jones and Dr. KM Dubowski. The last time I met Kurt in person was in February 2015 when the 67th annual meeting of AAFS was held in Orlando and when he was already in his 94th year. His hearing was impaired and his mobility was hampered, but his mind was as sharp as ever and his memory for people and places was excellent. Figure 5 shows a photograph of the two of us sitting at a table during a lunch meeting of the editorial board of Journal of Forensic Sciences (JFS). Kurt holds the distinction of being the longest serving member of JFS's editorial board, from the time of its inception in 1956 until the time of his death in 2017 (61 years) – another first!

Although we had our differences of opinion, Kurt was always open to discussion, especially when I was able to support my position with experimental data or by reference to credible

scientific literature. We disagreed about the usefulness of ethanol analysis in bladder urine and calculation of urine/blood ratios as an aid in the interpretation of time of last consumption of alcohol. Kurt was often very critical of back extrapolation of BAC and/or BrAC from the time of sampling to the time of driving, which is a necessary requirement in some US states [59]. However, he seemed to be ambivalent about this because occasionally he did such calculations in criminal cases without much hesitation. His negative views on back-calculating is evidenced by a sentence from one of his publications *"Finally, no forensically valid forward or backward extrapolation of blood or breath alcohol concentrations is ordinarily possible in a given subject and occasion solely on the basis of time and individual analysis results"* [59].

We also disagreed about the significance of a so-called "steeping effect" an expression coined by Kurt to account for irregularities in BAC and BrAC profiles when repetitive tests are made at short time intervals during the post-absorptive phase of the BAC curve. In one paper he wrote *"Breath and blood alcohol time curves are subject to short-term fluctuations from the trend line and other irregularities, and often do not follow the typical Widmark pattern"* [59].

Kurt was an oracle of information about forensic and biomedical research and his knowledge of the scientific literature was supreme, including articles written in German and published in BLUTALKOHOL. I once referred to him as a walking encyclopedia or maybe today he would be a mini-Wikipedia. He was a great storyteller and possessed a rather dry sense of humor, but could take a joke, even when it was on him. I once prepared a slide showing an expert witness with one hand on the Bible just about to be sworn in before testimony. The caption on the original slide read *"Is this really necessary, your honor? I'm an expert."* I substituted the original caption (from the New Yorker Magazine) with *"Is this really necessary, your honor? I'm Dr. Kurt Dubowski."* Kurt laughed and asked me for a copy of the slide, which he then began including in his presentations on the Borkenstein alcohol course at Indiana University.

Sometimes Kurt could be confrontational and was not always easy to deal with, because he was so outspoken regarding scientific issues and best practices and he certainly didn't suffer fools gladly. Defense attorneys faced with the task of cross-examining him in a DUI or DWI case could find him especially troublesome and he might answer a badly formulated question, with a comment such as *"let me try to untangle that for you counselor."* He held a thinly disguised contempt for movers and shakers in the field of forensic science and toxicology. During my many encounters with him, I soon realized that there were two ways of doing something, there was Kurt's way and then there was the wrong way!

I recall an incident in Bloomington once when we were leaving a local restaurant after having eaten dinner together. On the way to the car I happened to ask Kurt what the initial "M" stood for in his name (Kurt M Dubowski). Knowing of his German roots, I suggested that it might stand for Manfred. Kurt then took out his wallet and showed me his driving permit where it stated Kurt "Max" Dubowski. Then I asked whether Max was short for Maximilian, another common given name in Germany. He turned to me and answered abruptly *"what is the matter with you Wayne, haven't you seen the movie GLADIATOR, Max is short for Maximus"* (in Latin Maximus means greatest!).

Concluding remarks

The passing of Dr. Dubowski, just a few weeks before his 96th birthday, brings to an end a golden era in US forensic

toxicology especially the science of blood- and breath-alcohol testing. This tribute has focused on KMD's many contributions to knowledge about forensic aspects of alcohol and other drugs of abuse. Kurt was the last surviving charter member of AAFS and when the 70th anniversary meeting was held in Seattle earlier this year his major contributions to the organization were recognized in various ways.

Dr. Dubowski himself once summarized his research interests and contributions as *"being in both medical and forensic sciences, encompassing development of innovative methodology, human studies, and clinical and forensic applications of chemistry and toxicology."* Kurt was methodical and meticulous in everything he did and this included the clothes he wore (Brooks Brothers), the way he dressed, the ubiquitous tie-bar, his Rolex watch, and Mount Blanc pen, first-class air travel etc. His level of neatness and organizational skills were unsurpassed, his letters were perfectly formulated and his writing style was clear and direct, and in this respect he was a wordsmith. Kurt excelled in "setting the wheels in motion" in matters he considered important for the profession of clinical and forensic toxicology, such as the need for laboratory accreditation, certification of practitioners, and quality assurance of analytical results used in criminal and civil cases.

His teaching and his lecture slides were planned to perfection, and although he always placed a stop-watch on the table in front of him he rarely finished showing all his PowerPoint slides. The reason for this was his many side-stories, anecdotes and behind the scenes information about the people he had known and interacted with during his long career. These included such luminaries as Morton Mason (1902-1997), Rolla Harger (1890-1983), Robert Borkenstein (1912-2002), Robert Forney Sr. (1916-1983), Irving Sunshine (1916-2006), Alan Curry (1925-2007), Robert Cravey (1925-2010), Leonard Goldberg (1911-2010) and many others.

Some might recall his trademark "dbd" or "done by Dubowski," which was located in the bottom right hand corner of the slides he showed. And Kurt actually held a copyright on the materials he showed during the Borkenstein Alcohol Courses at Indiana University. However, he was very generous with his knowledge and if you asked for permission he willingly lent you slides or furnished you with reprints of publications he had authored. Kurt was also very generous and inspirational whenever he was asked to present a colleague for an award or distinction; no one could articulate a person's career achievements better than Dr. Dubowski. When I received the IACT Dubowski Award in April 2017, because of Kurt's age and failing health he was prevented from attending the meeting. However, to my delight he had made a video and this was shown during the presentation ceremony. In the video Kurt reviewed my research accomplishments over a period of 40 years and this is now available online (<http://www.iactonline.org>), and is probably his last ever formal presentation.

Dr. Dubowski was a longstanding resident of Moore, Oklahoma and in May 2013 this location was devastated by a tornado that ripped through the area, totally destroying his home and his belongings. Kurt was an avid collector of memorabilia, including pocket watches, law enforcement agency badges, hats, all kinds of books, music, weapons and much more. This natural catastrophe occurred when Kurt was over 90 years of age, and this might have broken the spirit of such elderly people to survive, but not Dr. Dubowski, who salvaged what he could from his possessions and re-located and set-up home in another part of Moore.

With the death of Dr. Dubowski the scientific disciplines of

clinical chemistry, laboratory medicine, forensic science and forensic toxicology have lost a veritable pioneer. Kurt lived and breathed science and his name will always be linked with the subject of forensic alcohol testing in the same way as sterling is associated with silver – mission accomplished!

Acknowledgement

It is a pleasure to acknowledge several people for their input in the preparation of this article about the life and work of Professor Kurt M. Dubowski. They read and commented on the manuscript and all knew its subject (KMD) well. These individuals are Patrick Harding (Wisconsin), Bob Zettl (Colorado), Rod Gullberg (Washington), Boris Moczula (New Jersey) and the lady in Kurt's life, Natalie Essary (Oklahoma), his companion and confidant for 64 years.

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