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In memoriam: Mark W. Mahowald, M.D. 1943–2020

The world of sleep medicine and sleep science has just lost an outstanding colleague, beloved teacher and mentor, champion of clinical and basic sleep science collaboration, highly original thinker, and ground-breaking investigator of the parasomnias and dissociated states of sleep and wakefulness. Mark Mahowald also helped advance knowledge of the causes of sleep violence that greatly informed the burgeoning field of forensic sleep medicine. He was one of the three founding members of Sleep Forensics Associates (SFA) in 2005, together with colleagues Carlos Schenck and Michel Cramer Bornemann, which has served as a critical resource for the law enforcement and legal communities for disseminating scientifically valid, non-biased information that has assisted attorneys for both the defense and prosecution in legal cases. Their SFA group has gathered the largest series of sleep forensic cases from a single center, with their cumulative data on 351 cases published last year in *Chest*. Mahowald was instrumental in identifying a new forensic sleep medicine category, viz. Parasomnia Pseudo-Suicide, that was published by his group in the *Journal of Forensic Sciences* in 2003.

Mark Mahowald played a major role in accelerating the development of the field of Sleep Neurology, and was the first author of the American Academy of Neurology (AAN) comprehensive publication CONTINUUM: Sleep Disorders in 1997. He served on the Neurologic Disorders Advisory Committee that helped the American Academy of Sleep Medicine (AASM) develop the International Classification of Sleep Disorders (ICSD) in 1990, and played important roles with the ICSD-2 (2005) and ICSD-3 (2014). His deep commitment to collaborations among basic sleep researchers and clinical sleep investigators was exemplified for more than two decades by his participation as faculty in the yearly Lake Arrowhead Workshop on Sleep Science, founded by Michael Chase from UCLA.

Mahowald also distinguished himself in the area of public service in sleep medicine. He served as President of the AASM from 1992 to 1993, and was the recipient of two AASM awards: the 1998 Nathaniel Kleitman Distinguished Service Award, and the 2003 Mark O. Hatfield Public Policy or Advocacy Award. He advocated tirelessly with Minnesota lawmakers to push back the start times of schools to enhance teenagers' learning. His work was frequently the subject of prominent newspaper and magazine articles and television appearances.

Mark Mahowald's dedication to public service throughout his career was displayed during the decades he spent as a staff neurologist and then Chief of Neurology at Hennepin County Medical Center (HCMC) and Professor of Neurology at the University of Minnesota Medical School in Minneapolis. The Minnesota Regional Sleep Disorders Center (MRSDC) was founded by the department of Neurology at HCMC in 1978, with the dual mission of serving patients afflicted by sleep disorders and of creating a multi-

disciplinary group of physicians (including pediatric sleep specialists) who could best manage patients across a full range of sleep disorders that often were comorbid with medical, neurological and psychiatric disorders. This was a visionary approach to patient care in sleep medicine. The high point of each week was the Tuesday noon staff meeting, which soon became known as Tuesdays with Mahowald. This meeting was described in the *New York Times Sunday Magazine* cover story on February 2, 2003, "The Man Who Mistook His Wife For a Deer", in which Mahowald was quoted: "We study the strange and the beautiful." He served as Co-Director and then as Director of the MRSDC from 1982 until he retired in 2010. Subsequently he traveled once monthly to Stanford where he ran a hugely popular parasomnias teaching clinic with the sleep medicine fellows. And he continued to regularly attend and actively contribute to the MRSDC Tuesday noon meetings.

Mark was known to say with genuine enthusiasm, "I can't believe I get paid to work here!" He taught courses on sleep medicine to medical students, and organized medical student teaching rotations at the MRSDC, where he also directed a sleep medicine fellowship, with the fellows representing all medical specialties and coming from around the US and from other countries. His passion for teaching these fellows is reflected in their continuing accolades. For decades Mark Mahowald was an invited speaker at prominent national and international sleep and neurology meetings, and at renowned universities across the world. He was a tireless reviewer of manuscripts submitted to major journals.

Mahowald's notable expertise with polysomnography, EEG, and nocturnal seizures was critical to his insights and discoveries with the parasomnias. A striking example comes from the MRSDC discovery of REM sleep behavior disorder, with the index patient evaluated by CHS (on his first day practicing sleep medicine) on September 11, 1982 and then undergoing video-PSG five nights later. As Schenck later wrote about what he had witnessed the next day (*Paradox Lost*, 2005):

"The next morning, in reviewing Don Dorff's polygraphic sleep tracings and videotaped behaviors, Mark Mahowald, M.D. and Andrea Patterson, R.PSGT & R.EEGT, our sleep center director and our sleep laboratory manager and chief technologist, repeatedly challenged each other, going back and forth in playing 'Devil's advocate.' The question was whether Don's violent dream-enacting activity had occurred during REM sleep ... So kudos to Mark and Andrea, who jointly discovered the polygraphic foundation of REM sleep behavior disorder-RBD."

At the MRSDC Mark Mahowald and his longstanding collaborator Carlos Schenck, and other colleagues formally identified and named the following conditions, beginning in 1986: RBD, Parasomnia Overlap Disorder (RBD + NREM parasomnias), Status Dissociatus (mixed states of REM sleep/NREM sleep/wakefulness—a

crowning discovery reported by Mahowald, according to Schenck), Sleep Related Eating Disorder, Sleep Related Dissociative Disorders, and Epic Dreaming. Mahowald had an avid interest in identifying the range of secondary parasomnias, ie, parasomnias emerging from other sleep disorders, medical/neurological disorders and medications. The cumulative knowledge gained from these discoveries was distilled in Mahowald's 2005 *Nature* paper (together with Schenck): "Insights from studying human sleep disorders." In 2007 Mahowald, together with Isabelle Arnulf from Paris, and Schenck formulated the first classification of "Sleep and Sex: What Can Go Wrong?" that was published in *Sleep*. Across multiple editions of *The Principles and Practice of Sleep Medicine*, edited by Kryger, Roth, and Dement, the foundational textbook of our field, Mark Mahowald and colleagues contributed chapters on RBD, NREM parasomnias and sleep forensics. He also contributed chapters regularly to nearly all the major textbooks, besides his numerous peer-reviewed journal publications.

The 28 year Mahowald-Schenck collaboration, from 1982 to 2010, at the MRSDC was a highly fruitful collaboration between a neurologist and a psychiatrist within sleep medicine, and involving quite different albeit very compatible personalities. The success of this collaboration can be indicated in part by their joint peer-reviewed journal publications: they were the sole authors together of 36 articles (including Editorials and Commentaries), and authors with additional authors in another 47 articles, besides their book chapters, published letters and abstracts. The following comment can also be offered: Mark Mahowald had a primary interest in the phenomenon of "state dissociation" and utilized the various parasomnias discovered at the MRSDC to further expand knowledge on state dissociation, as described in his elegant first-author seminal publications. This approach also greatly deepened the ties with basic sleep science. Schenck had more of an interest in gathering the narratives of the patients and spouses of the newly identified disorders to better understand the phenomenology and human dimension of these disorders, together with an interest in delving deeper into these newly identified disorders and their progression over time. This approach led to the important finding that RBD in older adults is a common herald of future alpha-synuclein neurodegenerative disorders, as first reported in *Neurology* in 1996 (10 years after the original report on RBD in *Sleep*). This finding propelled a large body of subsequent clinical and basic science research, and the formation of the International RBD Study Group in 2007. Clearly the primary interests of these two collaborators were strongly complementary. The first RBD textbook was dedicated to Mark W. Mahowald (and to Michel Jouvet who developed the first experimental animal model of RBD in 1965): "Rapid-Eye-Movement Sleep Behavior Disorder"[1].

Mark W. Mahowald, together with Carlos H. Schenck, received the "William C. Dement Academic Achievement Award" from the AASM at the Associated Professional Sleep Society meeting in June 2007 in Minneapolis, where Mark delivered the Opening Ceremony keynote lecture: "Listening to a Tinkering God—Opportunities for Sleep Medicine". Mark Mahowald and Carlos Schenck also received the Sleep Research Society "Outstanding Scientific Achievement Award" in June 2010, and the "Sleep Science Award" from the AAN in April 2017 for their discovery of RBD and its strong link with parkinsonism.

One of the authors of this obituary (JAH) provided the following description of Mahowald's legacy from a basic science perspective:

"A seminal contribution was Mark Mahowald's concept of the self as a constantly shifting set of states with multiple component elements. As a neurologist, he gave this idea clinical import in his work with Carlos Schenck on RBD. They recognized not just a new disease but an instructive condition.

Symptoms and normal psychophysiological features (such as muscle tone, mobility itself, hallucinatory perceptions and delusions) could all be better recognized by a quantitative statistical model rather than the linear model of traditional medicine. A person has one or more of the components some of the time whereas at others, he may have few or none of these manifestations. State dependence is the very essence of sleep medicine.

Mahowald's unusual sensitivity enabled him to maintain contact with and an appreciation of basic science at a time when sleep medicine was in danger of losing contact with its roots in neuroscience. Related to his inclusive and warm personality was his genuine enthusiasm for fundamental phenomena rather than mere surface appearances. He moved effortlessly from the bench to the bedside, and from brain to mind, and back again. Thus Mark Mahowald was a true pioneer of the new BRAINMIND science."

The last paragraph described Mark Mahowald's "inclusive and warm personality." In testimonials published online at the AASM and World Sleep Society websites, and from numerous personal interactions, there were recurring themes of kindness, warmth, selflessness, generosity, enthusiasm, passion, inspiration, charisma, intellectual stimulation, and superlative teaching. Mark Mahowald was described as being always approachable, with a "genuine love of the field", and left a legacy of innovation and excellence. His unique, colorful, and humorous language, witty quips, "large personality", and boisterous laugh were noted by virtually everyone, for whom he left a lasting and highly favorable impression.

Mark not only poured his heart and soul into his work, but also towards his family and friends to whom he provided unconditional love, support and cheerleading, always wrapped in kindness, humor, and wit.

His last great act of kindness took place on January 24, 2019 when he spent 12 h being the driver and companion of CHS during the latter's "gamma knife" therapy of a congenital arterio-venous malformation in the cerebellum that had recently ruptured. Four days later, on January 28, 2019 Mark suffered a right cerebral hemisphere stroke that resulted in a left hemiplegia, but fortunately spared his language ability. And being aquatic, he thrived on his weekly pool therapy. After a period of time, he was able to be brought periodically to participate in the Tuesday staff meetings at the MRSDC, a gratifying event for everyone. Over the last year he anticipated and thoroughly enjoyed frequent visits from friends and family, and thrived on the exhortations from his therapists and aides that kept him forging on. However, on March 18, 2020 Mark Mahowald succumbed to pneumonia, resting peacefully with his daughter Carrie and son Soren, grandson Joe, and former wife Maren by his side.

Mark's other biographical highlights include his birth on September 27, 1943 in Edina, MN, his graduation from St. Olaf College, a Pediatric internship at Michael Reese Hospital in Chicago, a two year stint in the Army served in Okinawa, followed by a Neurology residency at the University of Minnesota.

Finally, given the sum total of what has been written in this obituary, is there anything that Mark W. Mahowald has not done for our field of sleep medicine and sleep science, and with such magnificent and magnanimous style? His mentoring and wisdom will live on in all those whose lives he touched, and his published works will serve as guideposts for future generations.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: <https://doi.org/10.1016/j.sleep.2020.04.003>.



Mark W. Mahowald

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