CANINES

THE ORIGINAL BIOSENSORS

edited by **Lauryn E. DeGreeff | Craig A. Schultz**

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JENNY STANFORD
PUBLISHING

Published by

Jenny Stanford Publishing Pte. Ltd.
Level 34, Centennial Tower
3 Temasek Avenue
Singapore 039190

Email: editorial@jennystanford.com
Web: www.jennystanford.com

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

Canines: The Original Biosensors

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ISBN 978-981-4968-04-1 (Hardcover)
ISBN 978-1-003-26113-1 (eBook)

Dedication

This book is dedicated to FBI Supervisory Special Agent, Rex Stockham, for whom we cannot express enough gratitude for his guidance and experience. Rex was never afraid to ask a question, challenge an assumption, seek out an answer, apply a new type of learning technology, or set a new standard with forensic canines. His influence continues to drive research and raise the bar in an industry that is hungry for knowledge and for those who seek out innovative ways to utilize canines for detection, and it will continue to do so for many years to come.

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Foreword

I have actively been training dogs in the law enforcement canine community for forty years with emphasis on detection dog research and training, in both the public and the private sector. In parallel, since 1980 I have been a former prosecutor and now private practicing attorney and counselor at law, emphasizing practice in the area of the 4th Amendment and canine detection search and seizure. I have over twenty years of law enforcement experience and on many occasions have qualified as an expert witness in both State and Federal Courts in support of law enforcement. I am General Counsel for the California Narcotic Canine Association. I was a founding member, on the Board of Directors General Counsel for the Scientific Working Group for Dog and Orthogonal Detector Guidelines (SWGDOG). I am currently a member of the NIST/OSAC Subcommittee for Dogs and Sensors. It is an absolute honor and privilege to recommend this book and to give the reader a preview of what to anticipate.

Funded by the National Institute of Justice, SWGDOG was established in 2005. The goal of SWGDOG was to establish best practices for detection dogs delving into many varied detection disciplines. The best practices which followed from the combined output of SWGDOG resulted in the improvement of dog team training and operational methods and strengthened the credibility of related court testimony. In 2014, SWGDOG transitioned to The National Institute of Standards and Technology (NIST), an agency of the United States Department of Commerce, Organization of Scientific Action Committees (OSACs) becoming the Dog and Sensors Subcommittee. Moving forward, it is the intent of OSAC's Dog and Sensors Subcommittee to make SWGDOG best practices national industry standards.

With the established best practices of SWGDOG and the forthcoming national standards from OSAC's Dogs and Sensors Subcommittee comes the *need* to quench the thirst of each and every one of us who desires to take a drink from the well of dog

detection knowledge. Whether a trainer, end user operator, unit supervisor, researcher, or scientist, this publication will provide well-established, new, and/or supplemental enhanced information resulting in a step(s) closer to the most achievable success possible as it applies the many specific and varied topics encompassed within the content of this book.

The book offers a highly focused overview of both fundamental and advanced concepts in chemical sensing through canine olfaction, understanding the canine biosensor, training and evaluation of the canine biosensor and finally, formatting all the information into the real-world operational environment. Each chapter and the related topics are a compendium of clear and concise compartmentalized and varied specific knowledge and information with something for everyone. The text brings together the collective knowledge and experience of many world-class respected scientists and dog trainers. While there are many books in circulation on the related subject matter, think of this book as a clearing house of subject matter expertise that brings the 21st-century science and skill sets, technology, and methodology together to give the reader the ultimate learning experience. It is a collaboration of science and theory paired with real-world practical application. Figuratively, the best of both. Whether it is your first-time or next-time exploration into this subject matter, in all circumstances, the reader will have a huge positive takeaway component.

To improve is to change, the conscious decision to pursue the pathway to enhance and strive for the furtherance of valuable knowledge and education. So, invest in your improvement, enhance your skills, increase your knowledge, take the next step, read the book!

Happy hunting.

Mark Rispoli

Preface

Whether you are a practitioner, scientist, or simply a supervisor of canine teams, this book provides valuable insights for everyone involved with canine olfaction and detection. Here we have assembled a group of authors from diverse backgrounds ranging from academia to the operational detection canine community. These experts have been brought together to illustrate the ways in which science enhances our understanding of how canines are used to solve some of the field's toughest detection challenges. It is important to acknowledge the symbiotic relationship that exists between the scientist and the practitioner (handler and trainer). The keen insights of the scientist build the practitioner a foundation for which to stand on and reach new heights in our understanding of how these sensors operate, and it is the practitioner who poses the important questions that guide the scientific research.

To meet operational needs, the practitioner must be able to process massive amounts of information while working with the canine—another sentient being possessing its own thoughts and motivations. This task is no small feat. Collectively, handlers must have the courage to ask questions, share experiences, exchange ideas, challenge assumptions, and try new concepts. They must also ask questions the right way, develop sound methods to collect data, and provide relevant evidence so that new concepts can be proven or disproven. The pairing of the scientist and the practitioner makes a formidable team, and to create a better sensor, both are needed. Innovation is rarely successful without research and development. It is in this spirit that this book was produced. The text is organized into four sections. Each section is a grouping of selected manuscripts designed to complement each other.

A Dog's World: Chemical Sensing through Olfaction

These chapters give a glimpse into the manner in which canines may perceive the world. Visual acuity is not their only sensory

modality; they rely heavily on olfaction. That is why their innate olfactory prowess has been exploited by humans to locate otherwise undetectable odors of items or substances. The chapters in this section compare canines with mechanical sensors, giving readers a fresh perspective of their similarities, differences, strengths, and limitations. To do so, a chapter on the importance of applying figures-of-merit, sensitivity, and selectivity to canine detectors has been included discussing the dynamic nature of the canine olfactory system in different environments. To further expand the reader's view of canines as biosensors, sensor arrays (akin to the large variety of receptors of the olfactory system) are discussed as a form of biomimicry. To assess work in parallel fields, the last chapter in this section highlights advancements in chemical reception using insects as sensors. This seemingly unrelated topic will show how thinking outside the box and examining related fields can lead to future research and applications.

Understanding the Canine Biosensor: Fundamentals

For detection to occur, it is important to understand what odor is, what influences it in the natural environment, and what it means for the detection canine team. For example, living human scent is extraordinarily complex and has been a challenge for scientists to discern. As such, the way canines detect live human scent is an area where scientific exploration would be of great utility to the community.

This section further explores the canine as a biosensor and paints the picture of detection from physical and chemical aspects. Discussions of the neurobiological aspects of olfaction are examined to aid in the understanding of what transpires in the canine's brain when detection occurs. Here, new information is presented, and a new model is proposed to aid in our understanding of what human scent is comprised of, how it is produced, and how it persists in the environment. The final chapter in this section discusses how science supports and law influences the use of the canine as a sensor. It also provides legal considerations for canines used in forensic settings in the United States. Some aspects of this discussion may be viewed from a broader perspective as applicable to other disciplines.

Fostering an Effective Sensor: Training and Evaluation

A sensor is only effective as a tool if the mechanism and the operator are competent and work in tandem. The third section of this book focuses on the impact of training on canine performance and detection outcomes. This includes a chapter on the methods used to train the canine as well as considerations for preparing the team for live theater applications. Another chapter discusses how to create an optimal detector through assessing teams in all search contexts before deeming them as operational. A chapter on learning theory and ethology is provided to discuss how to accurately interpret behaviors associated with detection. A chapter providing an insight into the best practices for quality testing against a robust set of standards to qualify a team to be operational is included. Finally, another chapter discusses the intricacy of creating and delivering reliable sources of odor in testing and training environments.

The Canine Biosensor in Practice

This final section is a collection of chapters that highlight several of the many other ways in which canines serve as sensors. Their capabilities serve a multitude of purposes that deserve recognition. While all of the ways in which canines have been utilized would be impossible to capture, we have chosen to include examples of canine usage in novel detection fields, incorporating canines into detection regimes previously occupied solely by instrumental detection methods. Additionally, these examples will highlight the areas in which modern science has yet to develop a detector with the capabilities to rival the canine olfactory system. Eight individual chapters are dedicated to detection topics such as electronic storage devices, forensic uses, human diseases, and detection to mitigate oil spills. The final chapter in this section is a compilation of short vignettes of other interesting applications. It is our hope that readers will walk away with a deeper appreciation for the current work being conducted to find unique ways to utilize canines as sensors.

Throughout the book, readers may notice that some authors use the term “dog” while others use the term “canine.” The term canine has a more formal usage. The term dog is a more specific descriptor.

The Linnaean system of binomial nomenclature classifies animals into groupings. For example, "Canidae" is a broad family of animals that includes species including but not limited to wolves, coyotes, jackals, foxes, wild dogs, and bushdogs. Here, the domestic dog (*Canis lupus familiaris*) is referred to as "dog" and is more specific to the most common species used in detection. "Canine" refers to a group of species in the broader family of Canidae; thus, some feel as though the term is not descriptive enough. We felt that both have merit and have elected not to get mired down in vernacular and to accept both. The authors were allowed the freedom to determine which term to use in their respective chapters.

On a final note, the information accumulated in this book has been collected to aid practitioners and scientists in developing a heuristic viewpoint of the canine as a biosensor. The canine, while certainly equipped to be highly effective, requires a deep understanding of the vast and complex components that make it successful in detection. As such, canine application is not dissimilar to the scientist requiring an exhaustive appreciation for a detection technology prior to employing it in the field.

When practitioners are willing to ask questions, they become enlightened enough to observe and test with impartiality. When practitioners acknowledge a canine's umwelt and are able to evaluate environmental conditions, they become adept at assessing their partner's needs. This allows them to make necessary decisions to ensure success. When practitioners harness observational skills rooted in ethology and use the data gleaned from challenging assumptions, they become proficient in addressing problems when they arise. Data should be evaluated objectively, and as a result, mitigation strategies will be implemented with purpose, not hope, as a clear vision of success lies ahead. When practitioners seamlessly combine all of these components, they become capable of unleashing the most sensitive sensor on the planet. To date, there is no mechanical sensor that can reliably replicate the canine: the original biosensor.

Craig A. Schultz

"Lauryn DeGreeff, Craig Schultz, and their coauthors have performed a tremendously valuable service by surveying the whole world of dog odor detection with admirable clarity and thoroughness. This is a rich, clear, and very wide-ranging volume which scholars and practitioners will find tremendously useful."

Prof. Clive D. L. Wynne
Arizona State University, USA

"We are currently in a renaissance period with detection dogs. This book covers the immense skill and ability of the canine's nose. Enjoy this book and all the important information it shares."

Cameron Ford
Ford K9 LLC, USA

Detection canines have been utilized throughout the world for over a century, and while numerous attempts have been made to replicate the canine's ability to detect substances by mechanical means, none has been as successful. The olfactory system is a highly intricate and sophisticated design for chemical sensing, and the olfactory capacity of many animals, including canines, is considered unmatched by machine due to not only their great sensitivity and superior selectivity but also their trainability and mobility. These unique features have led to the use of such animals as "whole-animal" biosensors.

Amplifying the benefits and diminishing the limitations of detection canines' interdisciplinary research is crucial to understanding canine olfaction and detection and enhancing this powerful and complex detector. The past 50 years have produced vast advancements in animal behavior/training technology to develop canines into more proficient and reliable sensors, while scientific research has provided tremendous support to help practitioners better understand how to utilize this powerful sensor. This book assembles a diverse group of authors with expertise in a variety of fields relating to detection canines and the chemical sensing industry, including both research and operational perspectives on detection canines. It illustrates how science enhances our understanding of how canines are employed for solving some of the world's leading detection challenges.

Lauryn E. DeGreeff earned her PhD in forensic chemistry from Florida International University (FIU), USA, where she is presently a professor in the Chemistry Department and the International Forensic Science Research Institute. Prior to returning to FIU, she conducted her research as part of the Chemistry Division at the US Naval Research Laboratory in Washington DC. Dr. DeGreeff takes a chemistry-based approach to studying olfaction for the purpose of informing field vapor sampling practices. Her research focuses on trace vapor sampling, characterization, and generation in support of canine and other field detection approaches. Dr. DeGreeff regularly lectures on the dynamics of odor for the operational community.

Craig A. Schultz has 30 years of experience in animal behavior with organizations such as Disney's Animal Kingdom, Palm Beach Zoo, Jacksonville Zoo, the United States Department of Agriculture's National Detector Dog Training Center, and the Federal Bureau of Investigation. He has been a guest lecturer at several universities in addition to presenting at exotic animal, veterinary behavior, and working dog national conferences. He has also served as an active member of the Scientific Working Group on Dog and Orthogonal Detector Guidelines (SWGDOG) and the National Institute for Standards and Technology's Organization of Scientific Area Committee (OSAC) Dogs and Sensors Subcommittee.

V862
ISBN 978-981-4968-04-1
9 789814 968041

Jenny Stanford
Publishing