PREFACE

The unique and self-contained topic 'The vision of the bee' is of interest in its own right as the best-known example of what a typical medium-sized insect can detect with its eyes. It is also a topic of philosophical interest because it raises centuries-old questions about perception, consciousness, sentient beings, human uniqueness and insect-like robots. What does the bee really see? How does the small brain of the bee see so well? How does this influence our ideas about perception, automata and future practical applications?

There are many ways to answer these questions. Bees assist us because they can be trained to come to objects or patterns, and trained bees will answer questions put to them in simple tests. The bee's visual system is also open to analysis by optical, anatomical and electrophysiological methods, by tracking the bees while navigating and route finding and also by studying visual flight control as they pilot themselves between obstacles. This book includes a historical survey of how scientists have approached, experimented with and argued about insect vision for 100 years, finally rejecting anthropomorphism and solving some critical questions.

One of the features is the (still-imperfect) coverage of the German contribution to the subject. Until about 1966, insect vision was scarcely mentioned in books in English. The older work was ignored, while the more recent contributions were controversial and unrelated to each other. There was little study of the topic in England and textbooks made a hash of it.

This particular science is grounded in observation and logic. There is little mathematics, chemistry or physics involved or need for great learning. Bees are found worldwide and are reasonably representative of all large insects. Research on bee vision can be very cheap. The results have mostly been published but the story is not generally known or even available to the educated public. Here now is an account of what bees really detect with their eyes and how scientists found this out.

The accounts of earlier experiments on this road of discovery, and how inferences were made from the data, make a fascinating account of the arguments and counterclaims of contending professors. The approach here is out-and-out support for experiment, backed by the logic of John Stuart Mill and the philosophy of scientific progress of Thomas S. Kuhn. The processes of designing the experiments and inferring the conclusions from the data make a

miniature picture of scientific effort in several areas of biology, physiology and comparative psychology. They illustrate how the work was really conducted—not always amicably.

The basis of this study is the observation of the performance of bees. From the performance, an intuitive inference was usually made, as a stab at explaining the behaviour. Often, the inference was incorrect because the vision of bees was counter-intuitive in several ways. Explanations made by analogy with mammalian visual systems or drawn from the terminology of the cognitive sciences were usually found to be inadequate. There were many examples of excellent observations and reliable data, from which a wrong inference was made, followed by argument without new data, stubborn resistance to reinterpretation and refusal to accept advances made by others. Later, the mechanisms of the performance were analysed by extensive testing of trained bees and, after much thought, the counter-intuitive processing mechanisms of bees' strange visual behaviour were slowly revealed. The whole subject became an exposition of the stages of visual processing. Bees do not see shapes or objects; they detect parameters and recognise places. This story is told as an example of how early intuitive inferences have given way to the results of carefully designed tests of trained bees.

The book is intended for an audience who do not want a text crowded with references and every fact that exists. The aim is for it to be read more like an essay for anyone with some scientific background. It describes the process of scientific discovery on a limited theme, with two excursions into branches of the subject in more detail: the action of the retina and processing by the nerve cells (Chapters 5 and 6). For all chapters, there are sufficient names of researchers given for anybody who wishes to dig deeper, using the extensive bibliography. This book could be used by university students interested in subjects such as vision for physiologists, perception for psychologists, insects for entomologists or zoologists, robot vision for engineers looking for new ideas and scientific method for philosophers.