## PREFACE

*Fires of Life* is a scientific story that will help you to understand why your blood is routinely warmer than that of a gecko. The book is based on a career of research on the energetics of mammals and birds and on ideas generated by living and working in the southern hemisphere, far away from mainstream thinking in contemporary evolutionary physiology; it is inspired by an uneasiness that some ideas that science might have found useful in the eternal human quest to understand our universe might never have been debated or tested.

I am an evolutionary physiologist. The quest of all evolutionary physiologists is to understand the diversity of physiological patterns that make animals work in different ways in different environments. We ask questions such as, Why are some animals hotter than others? Why are some bigger than others? Why do some have saltier blood than others?

Why do birds and mammals have warm blood routinely, whereas other animals do not? This is the foundational question that I ask and attempt to answer in this book. It is by no means a trivial question. It is perhaps one of the most important questions in evolutionary biology. The answers will palpably boost your understanding of yourself and supply insight into the stupendous diversity of warmth in animals of the present and the past, including the dinosaurs.

Birds and mammals are the only animals that have the physiological machinery to keep themselves warm throughout a very cold day. They are endotherms, which means that they can generate heat on demand in their own bodies to balance heat that is lost from their bodies. Ectotherms are animals that do not, as a rule, have the capacity to produce heat on demand to replace lost heat. We once knew ectotherms as "cold-blooded" animals and endotherms as "warm-blooded" animals. For physiologists, however, these are inappropriate terms, because some lizards can attain warmer blood than that of mammals by basking in the sun, and some mammals can maintain a subzero body temperature when they are hibernating.

The massive difference between ectothermy and endothermy is the costs that are involved: endothermy is about ten times more "expensive" than ectothermy. So why did endothermy evolve when it is such an expensive way of living? Endothermy must have benefits that outweigh the costs—otherwise it would never have evolved. All evolutionary processes are driven by relative costs and benefits—what biologists term trade-offs. But what are the benefits of being consistently warm? How do these cold-hot trade-offs work?

Endothermy is indeed one of the greatest enigmas of evolution. The understanding of the evolution of endothermy has a very punctuated history. In the 1970s a flurry of hypotheses were published by pioneering thinkers such as Robert Bakker, Alfred Crompton, Brian McNab, Albert Bennett, John Ruben, and Roger S. Seymour on why or how endothermy evolved. These early ideas are all stitched into my timeline of the 300-million-year journey toward the supraendothermy that we see today in some birds and mammals. These early explanatory models, as well as several that Colleen Farmer and Pawel Koteja published three decades later, were "single-cause" models, which I argue are insufficient individually to formulate a holistic model on the evolution of endothermy. So the endothermy story has stagnated despite an enormous amount of research—for example, into one of its principal models, the Aerobic Capacity Model. It is hard to understand such stasis given that the evolution of endothermy was possibly the most critical innovation and evolutionary development during the evolution of birds and mammals. The endothermy story has become bogged down.

It is therefore timely to revisit the topic from new and different angles and along expanded time scales. With the insight provided by new paleontological data, such as splendid fossils of Jurassic and Cretaceous birds and mammals from China, for example, it is possible now to link the present with the distant past in a phenological framework—a working time model—on the evolution of endothermy. I truly intend the model to be a source of novel, testable hypotheses rather than a definitive treatise.

The book is not a maverick Gondwana alternative to the status quo; it shares with scientists and the informed reader a multitude of novel, peer-reviewed hypotheses about how, why, and when endothermy evolved in the two great lineages of vertebrates that produced the endotherms: the mammals of the synapsid lineage, and the dinosaurs and birds of the sauropsid lineage.

Part 1 of this book relates the story mostly from what we can glean from the study of fossils and starts more than 300 million years ago, when the first ancestors of the amphibians hauled out onto the muddy banks of swamps and started to eat plants. In Part 2, I tell the story from data that have been collected from living animals, much of it from my own work. These are new data that my students and I have collected in South Africa and Madagascar that support the argument that endothermy evolved for the most part in tropical Permian, Triassic, Jurassic, and Cretaceous forests, in an iterative, pulselike way. These eras were interspersed with intensely hot, arid periods that propelled the transition from ectothermy to endothermy in certain lineages.

I can list on the fingers of my hands the number of evolutionary physiologists who live and work in the southern hemisphere, compared with the many hundreds in the north. The small southern group includes a few who are as fascinated as I am by the evolution of endothermy. We share many common ideas that, in many respects, provide alternatives to those that have been taught and published by northern hemisphere biologists over the past century. I trust that my model and its hypotheses do their passion justice.

Although this book undoubtedly presents a few novel ideas that have yet to be vetted by my peers, for the most part it is centered on a peer-reviewed monograph published in *Biological Reviews*. The book itself also underwent several review processes managed by Yale University Press. For the sake of continuity of my story, I needed at times to take sides in some of the ongoing quarrels that may or may not have a bearing on the story of the evolution of endothermy. The debate about whether the major bird and mammal radiations occurred before or after the Cretaceous-Cenozoic boundary is especially vehement.

There are two types of physiology: mechanistic physiology, which asks how, and evolutionary physiology, my favorite, which asks why. Evolutionary physiology makes no sense, of course, without an appreciation of mechanistic physiology; but I have tried to minimize discussion of mechanistic physiology. Where it is essential for a continuity of understanding, I have relegated it to the appendixes. Students of physiology can simply refer to the multitude of physiology textbooks that explain how animals work. This book focuses on evolutionary physiology, on why there are differences in how animals work.

I cover climate change over 300 million years and trawl through the earliest proto-mammals and proto-birds that persisted through the Triassic heat. I discuss their remarkable explosion of diversity in the Jurassic, with animals that were the ancestors of the pterosaurs, dinosaurs, birds, and mammals.

It is a hot story.