Prologue

Why Yet Another Book About Evolution?

False facts are highly injurious to the progress of science for they often endure long; but false hypotheses [theories] do little harm, as everyone takes a salutary pleasure in proving their falseness; and when this is done, one path toward error is closed and the road to truth is often at the same time opened.
Charles Darwin (preface to *The Origin of Species*)

My introduction to evolution came early, just after I'd started elementary school. I was six years old and hung quietly in the background while my mother helped my sister illustrate the story of evolution on a 90-foot roll of kitchen shelf paper for her school science project. The scroll depicted the descent of living organisms from a single common ancestor, with each geological era plotted to scale, and the whole thing lavishly decorated with drawings and photos cut from an ancient encyclopedia. The finished product wrapped impressively around three walls of the fourth grade classroom, and there, near the very end of the roll, were humans and their ancestors—clearly occupants of an insignificant sliver of evolutionary time. The dramatic message wasn't lost on my sister's classmates—or on me.

At home over the next couple of years, evolution became the focus of many discussions over dinner and the impetus for family camping weekends to the shores of Lake Erie in southern Ontario. There we spent long summer days chipping trilobites and other fossil creatures out of the brittle shale, and evenings admiring our finds and discussing their evolutionary significance. Over one of the intervening winters of that period, I developed a fascination with wolves and sled dogs.

Jack London's adventure story of the Canadian North, *White Fang,* not only became my favourite book but defined my image of what a real dog should be. No matter that we lived in suburban Toronto—not the Yukon—or that I was barely ten years old: I campaigned heavily for a sled dog of my own.

My father relented after about a year and bought me a registered Alaskan malamute, the largest and strongest of the sled breeds. That wolf-grey female was the first of half a dozen malamutes who've shared my life over the years, and she remains the most memorable. Chaka had astonishing wolf-like moments, including a remarkably expressive howl. The combination of wild and civilized nature typical of this breed captivated me both intellectually and emotionally, and I've rarely been without one since.

Years later, malamute number three—a massive black-and-white male—was the first family dog for my own two children. When my son was about three, we saw a chihuahua being led down the street, prompting the familiar pointing and "Wha's tha?" His response to my answer left me dumbfounded. The disbelief and hurt on his face was as easy to read as a stop sign: "A dog? I'm not *that* gullible. I know what a *dog* looks like!" My glib reply was much easier than a real answer: "You're right," I said, "it's a pussycat."

It never occurred to me then to explain the concept of dog breeds to a three-year-old. It also didn't occur to me just how significant the incident was, biologically speaking. However, years later I realized that what I've come to think of as "the chihuahua conflict" actually says all there is to be said about what makes dogs special. Think about it—the term *dog* describes an animal with almost endless variation, so when we want to be really clear about what a particular animal looks and acts like, we use breed names. Most breeds of domestic animals not only have a distinctive, consistent appearance but often a characteristic temperament as well. In other words, for domesticates, the name of the *breed* describes animals of relatively uniform appearance and behaviour in the same way as the *species* name does for wild animals (such as the grey wolf, *Canis lupus*).

Figure P.1 The animal children understood a dog to be (here with daughter Laura)

When you think of it this way, breeds of domestic animals are similar in many respects to species of wild animals, because when individuals of the same breed mate, the offspring resemble their parents—and each other—to a large degree. Granted, all individuals (even so-called identical twins and higher multiples) are never absolutely the same—there is always some amount of difference, or *variation*, among them. Within a litter of puppies for instance, these differences among individuals can be physical (like contrasting hair colour or size) or behavioural (like the variations in temperament that make one pup bold and another shy). Other distinctions may exist that won't be obvious until later, like differences in resistance to disease. In spite of such variation, however, the result of humans carefully controlling which individuals are allowed to mate is that breeds of animals stay more or less the same, generation after generation, in the same way as species of animals do.

This control by humans over breeding is an essential and significant difference, of course (as we will see later). If dogs are allowed to mate indiscriminately, the breed distinctions disappear. Breeds remain similar to species only as long as our influence persists. As soon as people relinquish control over the mating habits of a breed, or cease to provide opportunities for mating within the breed, it becomes extinct—as well and truly extinct as any wild species can become. This has been the fate of many local varieties of dogs, including some European breeds that were lost during the chaos of the first and second world wars. Many local aboriginal varieties in the South Pacific, like the Hawaiian *poi-dog* and the New Zealand *kuri*, were lost through interbreeding with the European dogs that early settlers and missionaries brought with them. The one true native breed that appears to have existed in the Americas fared a similar fate, but for another reason. The Northwest Coast Salish wool dog (illustrated next page), bred for its long woolly hair, which was shorn and woven into highly-valued blankets on simple wooden looms, became extinct because of a sudden and irrevocable loss of effort in maintaining control over its breeding—within a few decades after Europeans arrived with their colourful Hudson's Bay trade blankets, the wool dog was no longer a breed distinct from other local dogs.

I suppose few people would ever think of breeds of dogs as species–equivalents. But after many years of study, I've come to the conclusion that understanding precisely why there are such similarities between breeds of domestic animals and wild species is paramount to understanding evolution. Charles Darwin came tantalizingly close to a similar conclusion more than one hundred years ago and I believe it's time to revisit this line of thinking. I suggest that in today's world, dogs—not fruit flies—may be the best models for studying and explaining evolution.

Fruit flies have become a popular subject for evolutionary studies because they can produce many generations of offspring in a year, and so the results of experiments that mimic natural selection can be seen quickly. But they're poor models when it comes time to explain how the process actually works to people who aren't scientists, for reasons that only begin with the fact that you can barely see a fruit fly without a microscope. More importantly, it requires a huge leap of faith for people to believe that what works for insects could transform apes into humans and leaps of faith, in my opinion, are not what science should be about.

Figure P.2 Extinct breeds are as forever lost as extinct species. Shown here, a sketch of a reconstructed Salish wool dog of the Central Northwest Coast of North America, a unique native (aboriginal) breed that became extinct so fast during the early years of European contact that no specimens were ever collected—it's known only from archaeological skeletal remains and historical descriptions. Artist Cameron J. Pye (see refs. 145, 153, 365).

For many people, the evolutionary processes of speciation and natural selection are much easier to comprehend, and to apply to our own evolutionary history, when domestic animals are the models. While Darwin would probably have chosen pigeons, I think dogs are a better choice for the twenty-first century. Most people—regardless of where in the world they live or what they do for a living—know something about the range of form and behaviour that dogs exhibit.

However, in order to use dogs—or any domestic animal, for that matter—as a model to explain evolution, some misconceptions have to be addressed. We've all been taught that dogs became domesticated because of human manipulation and design, that someone very long ago got the bright idea that a wolf might be a useful hunting assistant and so captured a few young pups to raise. Taming of these captive wolves is said to have begat dogs. Having had success with dogs, so the story goes, the same method was applied to wild sheep, goats and cattle—and lo, there was livestock.

In reality, this scenario of domestication is little more than a widely accepted myth. It's a story concocted by anthropologists to fit assumptions of human behaviour and historical events, but there's no concrete evidence whatsoever to support it. Although it's rarely challenged outright, a few people—myself included—have long been suspicious of this traditional definition of domestication, for reasons that I'll go into in more detail later. My own scepticism doubled, however, when a genetic research project on dogs and wolves I was involved in during the early 1990's didn't generate the results it should have if this concept of domestication was correct. This lack of correspondence didn't matter to the research project or to my graduate school supervisor, but it mattered to me: if domestication didn't happen the way we'd all been taught, how exactly *did* dogs come to be?

I lost patience with assumptions masquerading as fact and went looking for some scientific answers that made sense. As I will show in the chapters that follow, dog domestication is fully explainable as a natural evolutionary process, a true *speciation event* that did not require intentional human interference. The same can be said for all of the other major domestic animals (this doesn't mean humans *couldn't* have deliberately initiated domestication events, it just means they didn't *have* to). Although a few of my colleagues had made this argument before, it wasn't an idea that really caught on because none of them were able to suggest a plausible alternative explanation for how and why the changes we see in domestication actually came about.

I was able to come up with just such an alternative explanation for domestication because I took a very straightforward approach. I began by asking one simple question: what had to happen to a wolf, in strictly biological terms, for it to become a dog? My preliminary dip into the scientific literature, in January of 1994, suggested that vital information on the topic already existed: I didn't need to do research experiments myself because they had already been done. As often happens in science, however, no one had realized the broader significance of these experimental results—they saw only the immediate applications to their own work or to other problems of a similar nature.

I was hooked. I ended up reading volumes of material, searching the literature on embryology, reproduction, animal behaviour, physiology, genetics and endocrinology. I probably spent the equivalent of a Hawaiian vacation making photocopies of journal articles and book chapters. I talked incessantly with colleagues, visiting scientists, friends and family as I struggled to piece it all together. Although I knew full well that the whole thing might be a pointless intellectual exercise, I also realized that the seeds of this inquiry had been planted more than thirty years ago, at the time my childhood fascination with wolves and wolf-like dog breeds began. I felt I owed it to myself to follow the investigation as far as it would go and truly considered it a matter of personal indulgence.

However, within the year I realized I had not only an answer to my initial question but one that went much further. When I asked how a wolf could turn into a dog without deliberate human intervention, I came up with an explanation for how *any* animal could transform into something else—and it was clear to me that if my answer was valid for domestication, the concept simply had to work for evolutionary change in all other animals as well. My model not only explained *why* animals change from one form to another when they do, but also *how*—in intuitively comprehensible terms. In other words, I was able to turn my model for domestication into a general evolutionary *theory* that describes the invisible biological mechanism responsible for evolutionary change. Although in everyday use the word *theory* often serves as a synonym for *speculation,* in science a theory must be a general explanation that fits many situations—and must also be based on verifiable facts and testable by scientific methods.

My theory explains precisely how evolutionary processes could have transformed wolves into dogs *and* created new species of fish, birds and mammals (including primates and our immediate ancestors). With slight modification, it also works for plants and invertebrate animals, like insects. It's also scientifically testable: that is, it should eventually be possible to prove by experimentation that the concept is wrong—if indeed it isn't correct. It was, I'd like to think, the kind of answer Charles Darwin dreamed of finding.

Most people know that Darwin's theories about evolution revolutionized the way people thought about the world, but few realize the one significant thing he *didn't* do: he never actually delivered what the title of his famous book seemed to promise—a precise explanation for the origin of species. Modern biologists have not done much better despite decades of research by thousands of competent scientists. Ornithologist Ernst Mayr, who died last year at the age of one hundred, actively applied himself to this particular dilemma without success for well over sixty years (see William Provine's 2005 essay and refs. 504-511); Stephen Jay Gould, palaeontologist and author of many popular books and essays on evolution, did the same—although his approach was different and he didn't live as long (275-278). While both made significant contributions to knowledge about how evolution proceeds in theory and in practice, neither resolved the question of how species arise in precise biological terms.

As it turns out, both Gould and Mayr were far too deeply entrenched in the field of evolutionary theory to contribute a really novel solution to the species problem. Tom Kuhn explained this years ago in his classic 1970 volume, *The Structure of Scientific Revolutions* (updated recently by Robert Root-Bernstein in a livelier treatment called *Discovering: Inventing and Solving Problems at the Frontiers of Scientific Knowledge,* 1989): historically, solutions to seemingly intractable problems in science have always come from either outside a field or the edges of it, not from someone ensconced in the mainstream. Gould may have felt himself peripheral, but in the end he wasn't nearly close enough to the edge.

History shows not only that revolutionary concepts and inventions tend to come from outside a discipline but that discovery itself is only half the battle. The other half is realizing what you've found—and then letting people know about it. Often, for a very new idea, this last requirement is a real challenge. Hence this book, in this format. (And in regards to the format, I've chosen some particular conventions: references cited are listed by number *and* author/date in the bibliography; there is a short list of references geared to nonspecialist readers at the end of each chapter (designated *recommended readings*); as much as possible, complex details that may be of interest only to specialist readers are confined to shaded boxes.)

My theory for the role of thyroid hormone in evolution is destined to have a revolutionary impact, not just on the field of biology but on the practice of both human and animal medicine. At first glance, I might seem an improbable person to have come up with such a far-reaching concept—and my low-tech/low budget approach unlikely to have resulted in an important discovery of any kind. However, I had some important factors in my favour. First of all, I had the right educational background: an early childhood exposure to the concept of evolution, a bachelor's degree in comparative zoology and a graduate school upgrade in molecular genetics. All of this helped prepare me for reading masses of scientific papers on a diversity of subjects.

I had also chosen the right career. Having fortuitously taken all the right undergraduate courses, I jumped early on at an offer to enter the burgeoning field of *archaeozoology*, the identification and interpretation of animal bones recovered from archaeological sites. The process of building a career in this discipline had a huge impact on my evolutionary thinking. Archaeozoology depends on the fact that species, and their bones, are constant over time. The same thing is true for Stephen Gould's field of palaeontology: it's just that the time scale in archaeology is shorter and the bones are still bone (not turned to rock, as they are in fossils).

In archaeozoology, an ancient bone or bone fragment is compared with the same bone from a number of modern animals until a match is found. I became intimately acquainted with the skeletal anatomy of modern animals as I turned scavenged carcasses into the labelled skeletons that made up our reference collection of bones. What became patently clear was that despite slight individual variation, virtually every bone in the skeleton of a distinct species (not just the skull or teeth) is always the same shape regardless of when it was collected. A black-tailed deer thigh bone (femur) from five or ten thousand years ago might be slightly larger or smaller, but it's the same shape as one found today—and it's always distinguishable from the femur of a mountain goat. The femur of a white-tailed deer will be more similar to that of a black-tailed deer than to that of a mountain goat, but it will be distinguishable nevertheless. This basic premise is true for every kind of animal there is: fish, birds, both marine and terrestrial mammals, reptiles and amphibians.

I didn't need to accept an intellectual concept of what a species was and what it meant: I'd handled the proof of it—day after day—for twenty years. Archaeozoology provided me with a critical evolutionary insight that bridged the infamous gap between the view of life that a palaeontologist gets (biased because it has no living component) and the one that a field biologist gets (biased because it lacks an historical component). This unique perspective put me in a position to assess the question of how species arise from a totally new perspective.

In the end, I believe the main reason I was able to come up with an alternative explanation for domestication that made sense was simply that I asked the right question—at the right time. As it turned out, this was all that was really needed for the development of an entirely novel concept of how evolution works.

The timing component was really crucial: when you're trying to advance a new theory that contradicts what is currently accepted, no matter how well supported or eloquently presented, people need to be ready to hear what you have to say or you'll be talking to the wind. I found to my relief that many members of the scientific community were already questioning the reigning theoretical model of evolutionary biology (the accepted *paradigm*), which hinges on the primacy of the gene. Some might say such a challenge is long overdue. Certainly, it's clear that despite decades of research and billions of dollars in funding, biologists still have little more than the vaguest of explanations for how genes transform one species into another. They can list the DNA code for the entire human genome, but can't say which genes create the essential differences between ourselves and chimpanzees—or between ourselves and carrots, for that matter. In short, the current evolutionary paradigm has outlived its usefulness, and many biologists know this in their hearts even if they're not ready to admit it publicly. This isn't meant to imply that genes and their mutations aren't important, just that they are not necessarily the biological mechanism that drives the bulk of evolutionary change.

So why yet another book about evolution? What we need, and what I'm offering, is an opportunity for geneticists and evolutionary biologists to take a few steps backward—a chance to look at the problem again from a new, less "geno-centric" perspective. More than a few of my colleagues have already happily embraced the prospect. My theory requires thinking about how species change in a somewhat different fashion than most of us have been taught, but it doesn't contradict Darwin's basic tenets—it simply comes at the problem from a slightly different direction. My theory presents a new way of thinking that provides an intuitively understandable solution for some things we didn't understand before. It also resolves an increasing number of conundrums that have only come to light with recent advances in molecular genetics. The really unexpected bonus is that the concept also has profound implications for human and animal health. As a consequence, my answer to the question of how species arise actually makes evolution *personal*.

The battery of experimental tests of my theory have barely begun, which might prompt some of my colleagues to suggest this publication is premature. But I've come to realize that whether or not the theory is upheld, in totality or in part, it represents such an important new way of thinking about life that its value transcends absolute validation. Charles Darwin saw this about his own work, and the comment he made is equally true here: "False facts are highly injurious to the progress of science for they often endure long; but false hypotheses [theories] do little harm, as everyone takes a salutary pleasure in proving their falseness; and when this is done, one path toward error is closed and the road to truth is often at the same time opened."

I've written several peer-reviewed journal articles and book chapters on this topic, as well as a Ph.D. dissertation, in scientific formats appropriate for scholarly consumption (146-151). Encouraging responses to these publications from my colleagues assure me of the validity and usefulness of my theory. But non-scientists and scholars in unrelated fields were asking for a more accessible treatment, something more pragmatic and with less jargon. I hope this fits the bill. My aim with this book is to make evolution as comprehensible and personal for you as it's become for me. By the end of the story, you will really understand how evolution works, even if you thought you understood it before. I guarantee it will change the way you look at life.

Recommended reading

Kuhn, T.S. 1970. *The Structure of Scientific Revolutions, Second Edition.* University of Chicago Press, Chicago.

Provine, W.B. 2005. Ernst Mayr, a retrospective. *TRENDS in Ecology and Evolution* 20(8):411-413.

Root-Bernstein, R. S. 1989. *Discovering: Inventing and Solving Problems at the Frontiers of Scientific Knowledge.* Harvard University Press, Cambridge.