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Introduction

JUST OVER 150 YEARS AGO, in June 1858, the English naturalist Charles Darwin, tucked away in the Kent countryside, received a manuscript from a young colleague, Alfred Russell Wallace, presenting his thoughts on nature. So innovative were these ideas, and so like Darwin's own, finally about to be published after twenty years, that he determined to work on a joint publication with Wallace for the Linnean Society. This marked the beginning of a revolution in science, and a year later, Darwin published *On the Origin of Species*. The first printing sold out in a single day — lucky author! — and it is safe to say that nothing in biology was ever the same again.

Their main idea that species evolve and descend from one another — most of them disappearing in the great expanse of time — would change the way we see the world. If Darwin and Wallace had merely been content to present this theory, already advanced by others, their influence would not have been as great. But they went further, explaining natural selection,

the mechanism by which evolution occurred, and convincingly showing how it functioned. Because religious dogmas at the time preached that species were fixed and unchanging, an inevitable clash occurred.

Today, having just celebrated the 150th anniversary of its publication with exhibitions, books and films, the theory of evolution by natural selection is, for scientists, unshakeable. Of course, it does not explain everything in complete detail, even in much-studied organisms like mice, even more so in humans, but it is a solid scientific theory, tested and proven, despite repeated criticisms for more than a century. It is the indispensable framework in which to explain life. As the American geneticist Theodosius Dobzhansky said in 1973, “Nothing in biology makes sense except in the light of evolution.”

During the filming of a documentary for Radio-Canada in 2008, I asked Richard Dawkins of Oxford University — a well-known defender of Darwin, who has written eight books on the biology of evolution — about the role of Darwin’s ideas. Here is how he replied:

I think that Darwin’s idea is perhaps the most powerful idea that any human mind ever had in the sense that it did the most explanatory work that actually changed the way people think, because before Darwin came along, the whole of the living world, all this magnificent complexity and beauty and elegance and diversity had no explanation at all. People knew it was there, and they were describing it, but nobody knew what caused it; nobody knew how it came into being. Darwin changed all that.

For the rest of society, it may not be so clear. Among the broad public, the theory’s success is mixed. Often poorly known or understood, it is easily confused with gross oversimplification (“survival of the fittest,” for example). It is frequently challenged by fundamentalist religious belief, which is experiencing a resurgence across the globe, and my personal crystal ball tells me it will be a hot topic for years to come. Creationists or neo-creationists in the Intelligent Design movement will redouble their attacks on evolution, and this is all the more reason to discuss it publicly and show its full power and subtlety.

This public debate is partly the context that gives rise to the present book. It appears useful nowadays to discuss these fundamental ideas about

living things, as well as the gulf that separates scientists from the rest of society. If science is publicly repudiated, it loses credibility and its ability, notably among decision-makers, to solve important problems for the planet, especially climate change and the massive loss in biodiversity. Of course, not everything can be solved by science, but it does provide for an exchange of ideas that esoteric or religious beliefs cannot replace without leaving humanity and the planet at great risk.

This book springs also from the desire to provide concrete examples to show how the science of evolution has been refined over the past 150 years. Today, by integrating modern learning in genetics and molecular biology, that science is more powerful and unassailable than ever. Both Darwin and the ideas that have developed in his wake are important and fascinating.

For this reason, I have chosen a journalistic approach aimed at drawing attention to the newest elements of evolution. The “star,” it might be said, is what has come to be called “evo-devo,” a contraction used by specialists for “evolution and development.” Emerging in the past fifteen years, evo-devo is a new way of approaching evolution that relies on recent discoveries in the biology of embryo development and in comparative genetics. The expression evo-devo may, at the outset, seem a sort of specialist jargon and repel the uninitiated. It does lead, however, to a newer and deeper look at the world of living things, and it is an approach we shall hear more and more about.

In order to deal with the science of evolution, I have presented evo-devo themes and accomplishments through sample case histories. Frequently, a particular anecdote or situation leads to a discussion of a question with far broader implications, and a fresh perspective offered by modern biology. Thus, each chapter can be read as a stand-alone essay, much after the manner of Stephen Jay Gould, a true master in the field. As a consequence, the reader might want to approach them in no particular order and refer to the glossary when encountering words or concepts that are unfamiliar.

There is, nevertheless, a thread and a progression to the ideas, as indicated by their division into three parts. In the first chapter, I offer the familiar example of a wooded area in southern Quebec, revisiting what we have learned from Darwin and connecting it to what modern science has

shown us. Then in Chapter 2 we come to what DNA analysis has contributed to Darwin's intuitive but scientifically well-founded concept of a tree of life that includes all species. We will then see (Chapter 3) how all this knowledge applies to our catalogues of biodiversity and the review of the development of a well-known sea mammal, although perhaps not from an evolutionary viewpoint (Chapter 4).

In the second part we move into the thick of evo-devo and look at recent discoveries in architect genes that govern the making of animals (Chapter 5). The next chapter takes us into the world of finches, above all the famous Galapagos finches discovered by Charles Darwin (Chapter 6), but as we shall see, it is very much a story both contemporary and universal, concerning beaks, genes and climate change. Then we turn to two applications: the creation of paws from fins (Chapter 7) and the panda's curious thumb (Chapter 8). Next comes the sensitive topic of the disturbing genetic proximity between humans and chimpanzees (Chapter 9).

The third and last part deals with how humans play with the machinery of evolution — so much so that evolutionary changes have become rapid enough for scientists to refer to them paradoxically as “contemporary evolution.” We shall see examples of these changes but also some additional examples of species conservation, for if we are capable of harming animal and plant species, we can also help in their conservation.

Throughout, I have kept in mind all those who like to involve themselves in nature in their moments of leisure, and to this end I have often described personal experiences at our lakeside cottage. This is nature recomposed, of course, not untouched nature in the wildest state — as if such a thing still existed. Be that as it may, these are areas rich in animal and plant life that we cling to and wish to protect. To protect well, one must know well.

First, then, this book can be seen as an invitation to take a fresh look at nature as it surrounds us, wherever we are, in town or country. Canadians are certainly privileged to have ready access still to large swaths of nature, even wild nature reserves. Although many visit them, they may be unaware of what is offered there. No matter where we live in this country, we must become aware of the importance of the riches around us, riches we many not even suspect to be there.

Second, it has been my goal to lead readers toward science itself and show the strength of what it does at an essential level that concerns us all. It is not the simplest thing to explain how life forms are built, to explain the source of biodiversity, or what sets humans apart from the primates. In the background there is always the sense of how this touches us personally: each of us different, all of us cousins. The idea that all living things — from bacteria to men, salmon to birches — share the same genetic code has enormous implications. Finally, as Stephen Jay Gould says in *The Panda's Thumb*:

And then, of course, there are all those organisms: more than a million described species, from bacterium to blue whale, with one hell of a lot of beetles in between — each with its own beauty, and each with a story to tell.¹

The following pages contain a few of these stories drawn from recent research, often somewhat technical, though I have tried to tidy up the technical jargon. My goal is, above all, to offer the broadest possible public an essential part of what modern science has to offer, something I believe each of us can benefit from: an appreciation of the basis of living things.