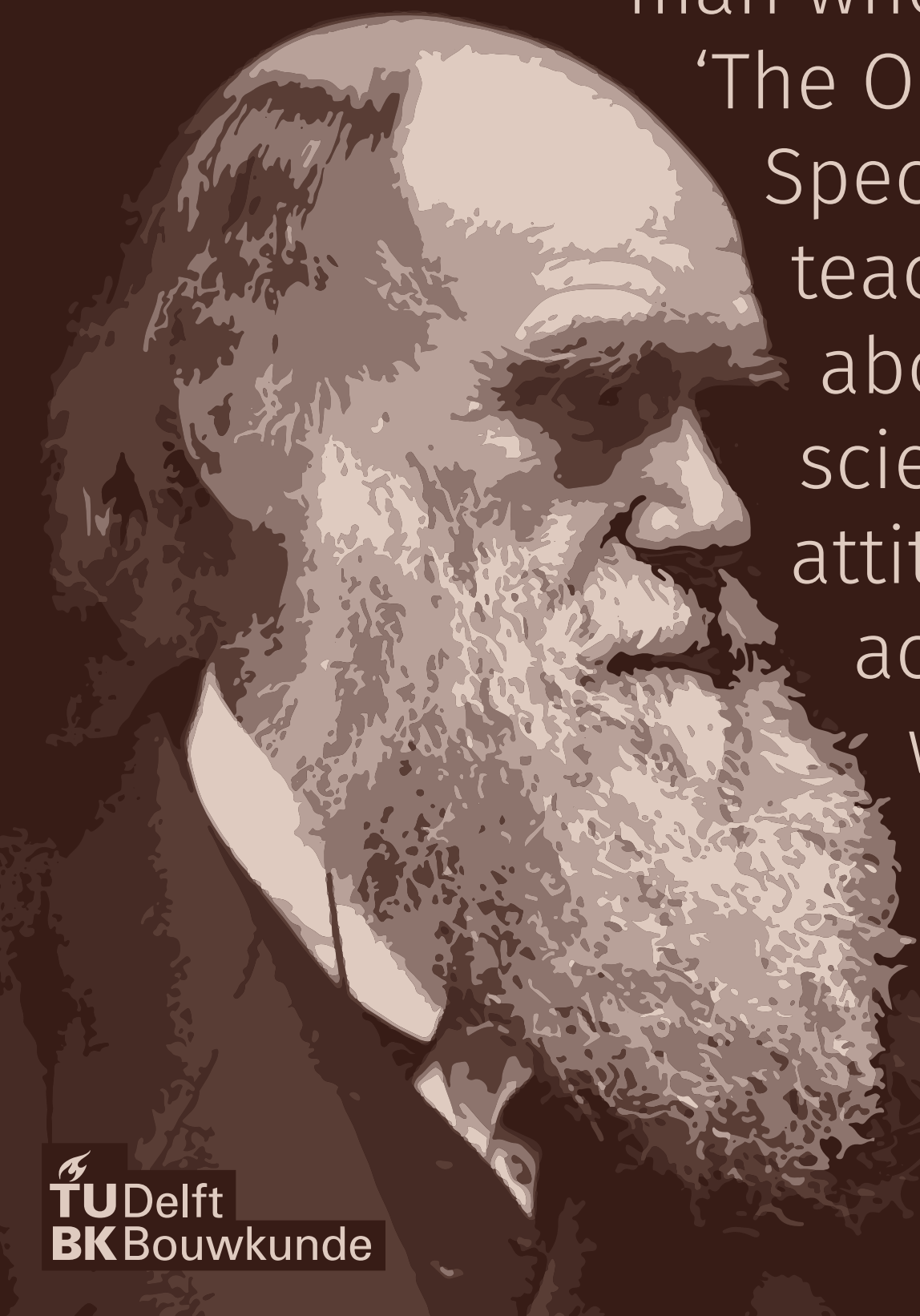
Learning from Darwin

What can the man who wrote 'The Origin of Species' teach us about a scientific attitude & academic writing skills?

by Roberto Rocco



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ISBN: 978-94-6366-073-0

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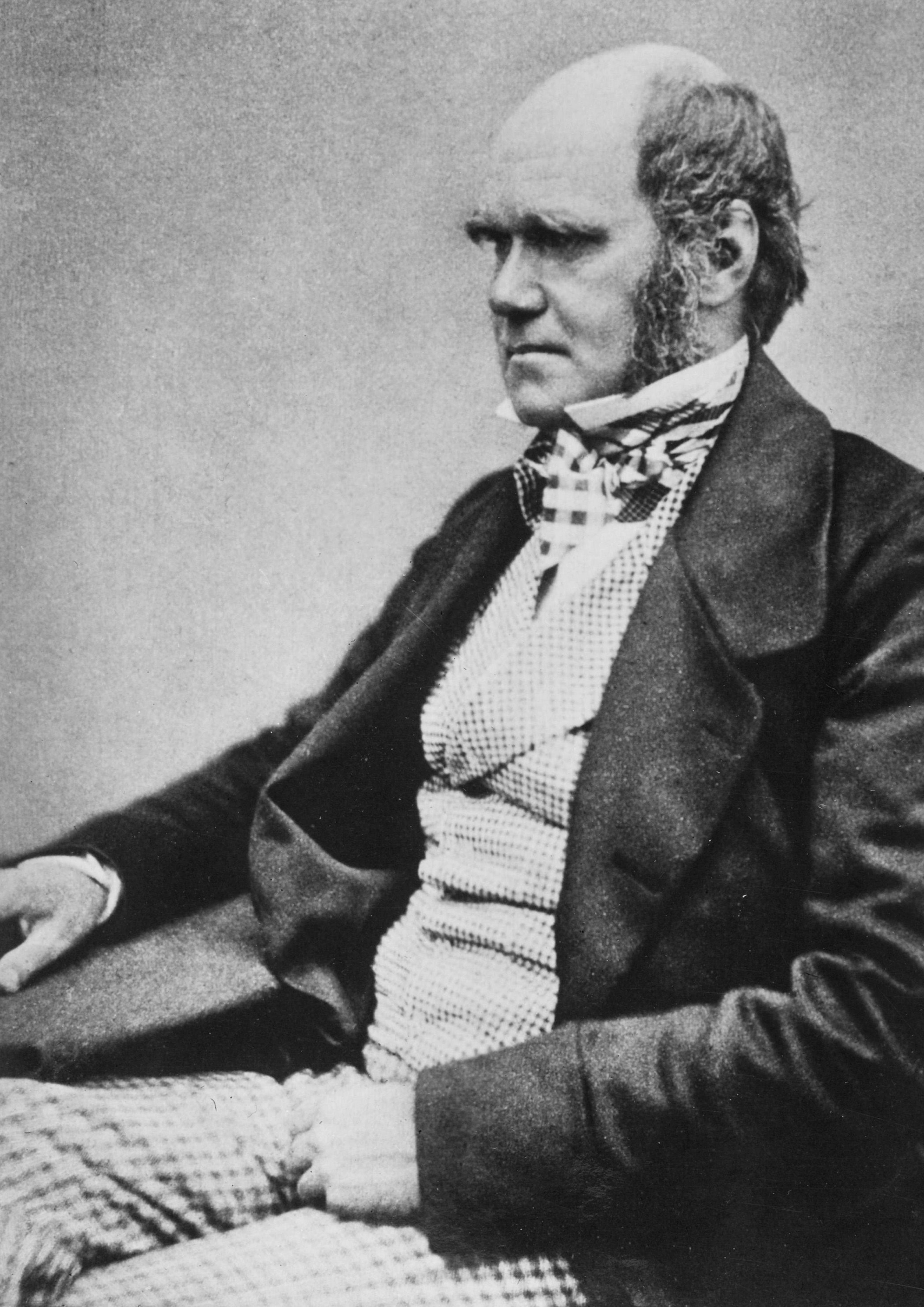


The test of reason and empirical observation

On the Origin of Species was published on 24 November 1859. It is a work of scientific literature by Charles Darwin, and it is considered the foundation of evolutionary biology. Darwin was writing at a time when the scientific method was still being perfected and lots of academic practices we now take for granted were being used by scientists at the time as novelties. Examples of these practices were citations, systematic referencing and careful and systematic recording of experiments and observations.

The Victorians were concerned about the order of their world and there was a big movement to classify the many species of living beings inhabiting the Earth . Classification was made on the base of careful observation of the external appearance and attributes of living beings (remember there was no DNA analysis available on those days).

Darwin, along with other scientists of the day, was worried about how so many different species had come to inhabit this world, and how it was possible that they were so perfectly adapted to their natural habitats and to each other. An accepted explanation to these questions at the time could be found in the Bible: God had created the world and everything in it, and subsequently created men and women in perfect harmony with his creation.

But, for Darwin, this narrative did not stand the test of reason and of empirical observation. Why so many species? Why so many slight variations? What about the fossils being recovered, which gave us evidence there were animals that no longer existed, but were clearly related to existing animals?

Darwin and others tried to answer these questions by applying rigorous observation based on empirical evidence and measuring of subjects to specific principles of reasoning. He used what we call "inference" to derive logical conclusions from controlled observations. Darwin's aims were twofold: to show that species had not been created separately, and to show that natural selection had been the chief agent of change.

This is an exercise elaborated for the Methodology course taught at the Masters track Department of Urbanism of the Delft University of Technology.

The objective is to present students with an interpretation of the introduction chapter of Darwin's seminal book, highlighting the elements that make it an enduring example of scholarship and style. This exercise is not intended as an exhaustive analysis of the text. It aims to discuss relevant points for students learning academic writing skills in English.

The version of the text written by Charles Darwin used here was published in London in 1872 by John Murray (DARWIN, C. On the Origin of Species, London: John Murray, 1872) and is made available by the Talk Origins forum at http://www.talkorigins.org/faqs/origin/introduction.html

Summary of Darwin's inferences

Below is a summary of what Darwin accomplished in his work. This summary was elaborated by the Department of Biology of the University of Miami, and is available at http://www.bio.miami.edu/dana/106/106F05_2print.html

* **Observation #1**. All species have huge potential fertility
* **Observation #2**. Except for seasonal fluctuations, populations tend to maintain a stable size.
* **Observation #3**. Environmental resources are limited.
* **INFERENCE #1**: The production of more individuals than the environment can support leads to a "struggle for existence," with only a fraction of offspring surviving in each generation.
* **Observation #4**: No two individuals in a population are exactly alike
* **Observation #5:** Much of the observed variation in a population is heritable
* **INFERENCE #2:** Survival in this "struggle for existence is not random, but depends, in part, on the hereditary makeup of the survivors. Those individuals who inherit characteristics that allow them to best exploit their environment are likely to leave more offspring than individuals who are less well suited to their environment.
* **INFERENCE #3:** Unequal reproduction between suited and unsuited organisms will eventually cause a gradual change in a population, with characteristics favorable to that particular environment accumulating over the generations.

Reading the introduction to 'The Origin of Species'

NOW WE WILL READ THE INTRODUCTION TO THE ORIGIN OF SPECIES AND DISCOVER TOGETHER WHAT DARWIN HAS TO TEACH US IN TERMS OF ACADEMIC ATTITUDE AND OF WRITING SKILLS. MY COMMENTS ARE MARKED IN A DIFFERENT COLOUR.

The text used for this exercise comes from: DARWIN, C. On the Origin of Species, London: John Murray, 1872).

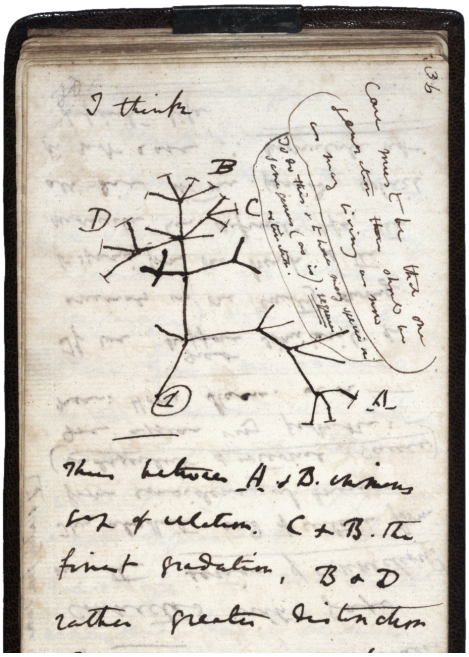
When on board H.M.S. Beagle, as naturalist, I was much struck with certain facts in the distribution of the inhabitants of South America, and in the geological relations of the present to the past inhabitants of that continent. These facts seemed to me to throw some light on the origin of species -- that mystery of mysteries, as it has been called by one of our greatest philosophers. On my return home, it occurred to me, in 1837, that something might perhaps be made out on this question by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it. After five years' work I allowed myself to speculate on the subject, and drew up some short notes; these I enlarged in 1844 into a sketch of the conclusions, which then seemed to me probable: from that period to the present day I have steadily pursued the same object. I hope that I may be excused for entering on these personal details, as I give them to show that I have not been hasty in coming to a decision.

In this introductory paragraph, Darwin gives a friendly introduction and entices the reader. The origin of species is the 'mystery of mysteries' and therefore worth HIS and OUR attention. Darwin is defining the RELEVANCE of what he did. At the same time, he is also telling us a bit about the method. He 'patiently accumulated and reflected on all sorts of facts. After careful and arduous work (5 years!), he allows himself to speculate on the subject and draw some 'short notes'. This is a rhetorical device: Darwin is modest in the way he presents his findings. In this way, he avoids excessively hard criticism and situates his research in a wider context of investigation, formulation and test of hypotheses.

My work is now nearly finished; but as it will take me two or three more years to complete it, and as my health is far from strong, I have been urged to publish this Abstract. I have more especially been induced to do this, as Mr Wallace, who is now studying the natural history of the Malay Archipelago, has arrived at almost exactly the same general conclusions that I have on the origin of species. Last year he sent to me a memoir on this subject, with a request that I would forward it to Sir Charles Lyell, who sent it to

the Linnean Society, and it is published in the third volume of the journal of that Society. Sir C. Lyell and Dr Hooker, who both knew of my work -the latter having read my sketch of 1844 - honoured me by thinking it advisable to publish, with Mr Wallace's excellent memoir, some brief extracts from my manuscripts.

Here Darwin situates his research in the context of the research on the subject of his day. This is important, because no one produces knowledge in isolation and, like all of us, Darwin belonged to a community of researchers seeking answers for similar sets of questions and using similar paradigms of enquiry (which means, as we know, that they also used similar methods of analysis and talked and wrote using the same jargon and the same technical terms). Not surprisingly, someone else had arrived at exactly the same conclusions as Darwin had! This is notable, because he sees it as a reason to publish his work as quickly as possible. He did not want to be accused of plagiarism, and defends himself by saying that he had researched the subject for more than five years already. In fact, he is afraid of something even more frightening for a scientist than plagiarism: lack of originality. It is important for scientists that their work is recognized as original, because this is part of what moves them: the creation and integration of new knowledge. Everyone understands the feelings of satisfaction of someone able to say: "this is my idea", or " I thought of it first", which guarantees the kudos (glory, status) that moves many men and women. It is not only glory that moves men, of course, but also a sense of accomplishment and service.



In mid-July 1837 Darwin started his "B" notebook on Transmutation of Species, and on page 36 wrote "I think" above his first evolutionary tree. Public Domain. Source: Wikipmedia Commons

This Abstract, which I now publish, must necessarily be imperfect. I cannot here give references and authorities for my several statements; and I must trust to the reader reposing some confidence in my accuracy. No doubt errors will have crept in, though I hope I have always been cautious in trusting to good authorities alone. I can here give only the general conclusions at which I have arrived, with a few facts in illustration, but which, I hope, in most cases will suffice. No one can feel more sensible than I do of the necessity of hereafter publishing in detail all the facts, with references, on which my conclusions have been grounded; and I hope in a future work to do this. For I am well aware that scarcely a single point is discussed in this volume on which facts cannot be adduced, often apparently leading to conclusions directly opposite to those at which I have arrived. A fair result can be obtained only by fully stating and balancing the facts and arguments on both sides of each question; and this cannot possibly be here done.

This is a crucial paragraph. Darwin again draws the attention of the reader to the limitations of the current version of his work and apologizes for not giving enough "references and authorities" to his statements. In fact, the number of references he could have given was quite limited, as the science he was ven-

turing in was largely being built as he wrote. However, and this is a crucial point for us: by referencing other authors we seek to situate our work in a wider context of research and knowledge production, but we also seek to give "authority" to our arguments. By "standing on the shoulders of giants", we can see further, as Sir Isaac Newton is claimed to have written. But we can also claim authority, by relying on the perceived authority of others who came before us and dedicated themselves to similar themes. Darwin is extremely cautious: he wants to make sure the reader understands his work has limitations, and he cautions the reader about the need to pursue arguments fully. Otherwise, he states, facts in isolation may lead to conclusions directly opposite to those he has arrived at. In fact, he is telling the reader that his arguments are complex and must be pursued in full.

> *I much regret that want of space prevents my having the satisfaction of acknowledging the generous assistance which I have received from very many naturalists, some of them personally unknown to me. I cannot, however, let this opportunity pass without expressing my deep obligations to Dr Hooker, who for the last fifteen years has aided me in every possible way by his large stores of knowledge and his excellent judgment.*

Again, Darwin is situating himself within a community of knowledge, often composed by people that he doesn't know personally, and he thanks that community for their 'generous assistance'. Acknowledging the contribution of your peers is very important in academia. After all, you want to collaborate with people and you want them to be sympathetic to your findings. A little bit of networking has never hurt anybody! Most importantly, acknowledging other people's contributions is the ethical thing to do.

> *In considering the Origin of Species, it is quite conceivable that a naturalist, reflecting on the mutual affinities of organic beings, on their embryological relations, their geographical distribution, geological succession, and other such facts, might come to the conclusion that each species had not been independently created, but had descended, like varieties, from other species. Nevertheless, such a conclusion, even if well founded, would be unsatisfactory, until it could be shown how the innumerable species inhabiting this world have been modified so as to acquire that perfection of structure and co-adaptation which most justly excites our admiration. Naturalists continually refer to external conditions, such as climate, food, &c., as the only possible cause of variation. In one very limited sense, as we shall hereafter see, this may be true; but it is preposterous to attribute to mere external conditions, the structure, for instance, of the woodpecker, with its feet, tail, beak, and tongue, so admirably adapted to catch insects under the bark of trees. In the case of the mistletoe, which draws its nourishment from certain trees, which has seeds that must be transported by certain birds, and which has flowers with separate sexes absolutely requiring the agency of certain insects to bring pollen from one flower to the other, it is equally preposterous to account for the structure of this parasite, with its relations to several distinct organic beings, by the effects of external conditions, or of habit, or of the volition of the plant itself.*

This is what we call a 'problem statement'. Darwin states very succinctly what te issue or problem at hand is. He states that it is conceivable, given the evidence available, that different species have not been independently

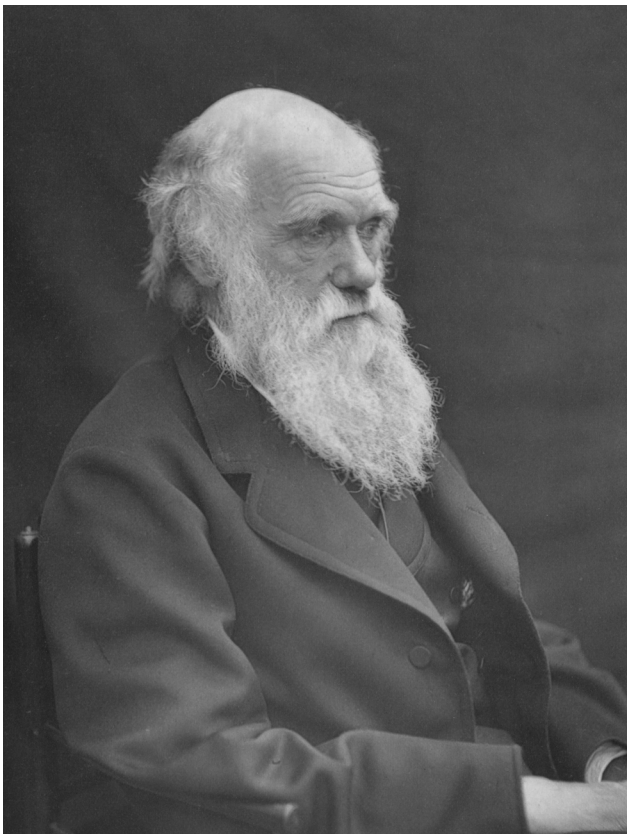
created, but most likely descend from other species. But he introduces a contradiction ("nevertheless"), by stating that this conclusion alone is not sufficient until it is shown "how the innumerable species inhabiting this world have been modified", that is, the CAUSALITY of variations. He is interested in the WHY and HOW species have come to be so varied and co-adapted. Different species seem surprisingly well adapted to their habitats, and they show signs of having co-evolved with each other. These characteristics are not explained by the belief that they descent from other primal species, so the process of adaptation and change must be influenced by other factors. What are they? And why does this happen?

The author of the 'Vestiges of Creation' would, I presume, say that, after a certain unknown number of generations, some bird had given birth to a woodpecker, and some plant to the mistletoe, and that these had been produced perfect as we now see them; but this assumption seems to me to be no explanation, for it leaves the case of the co-adaptations of organic beings to each other and to their physical conditions of life, untouched and unexplained. It is, therefore, of the highest importance to gain a clear insight into the means of modification and coadaptation. At the commencement of my observations it seemed to me probable that a careful study of domesticated animals and of cultivated plants would offer the best chance of making out this obscure problem. Nor have I been disappointed; in this and in all other perplexing cases I have invariably found that our knowledge, imperfect though it be, of variation under domestication, afforded the best and safest clue. I may venture to express my conviction of the high value of such studies, although they have been very commonly neglected by naturalists.

Here, he goes further circumscribing the problem and explaining why it is important to understand the process of evolution and coadaptation. He exposes one of the existing hypotheses around the problem announced earlier, but asserts that such hypothesis is not sufficient to explain the problem. Vestiges of the Natural History of Creation was published anonymously in England in 1844 (before The Origin of Species). It challenged many of the beliefs of the time and familiarized the public with the issues at hand. The book put forward a simple "theory of transmutation" and called it "natural history of creation", that is, it did not deny Creationism, but assumed things had "changed spontaneously" since creation. Darwin indicates GAPS in knowledge about the matter that must be filled and then proceeds to explaining what, in his opinion, is the path to take. He says it is necessary to "gain insight into the means", that is into the mechanisms that allow evolution and adaptation.

From these considerations, I shall devote the first chapter of this Abstract to Variation under Domestication. We shall thus see that a large amount of hereditary modification is at least possible, and, what is equally or more important, we shall see how great is the power of man in accumulating by his Selection successive slight variations. I will then pass on to the variability of species in a state of nature; but I shall, unfortunately, be compelled to treat this subject far too briefly, as it can be treated properly only by giving long catalogues of facts. We shall, however, be enabled to discuss what circumstances are most favourable to variation. In the next chapter the Struggle for Existence amongst all organic beings throughout the world, which inevitably follows from their high geometrical powers of increase, will be treated of. This is the doctrine of Malthus, applied to the

whole animal and vegetable kingdoms. As many more individuals of each species are born than can possibly survive; and as, consequently, there is a frequently recurring struggle for existence, it follows that any being, if it vary however slightly in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be naturally selected. From the strong principle of inheritance, any selected variety will tend to propagate its new and modified form. This fundamental subject of Natural Selection will be treated at some length in the fourth chapter; and we shall then see how Natural Selection almost inevitably causes much Extinction of the less improved forms of life and induces what I have called Divergence of Character. In the next chapter I shall discuss the complex and little known laws of variation and of correlation of growth. In the four succeeding chapters, the most apparent and gravest difficulties on the theory will be given: namely, first, the difficulties of transitions, or understanding how a simple being or a simple organ can be changed and perfected into a highly developed being or elaborately constructed organ; secondly the subject of Instinct, or the mental powers of animals, thirdly, Hybridism, or the infertility of species and the fertility of varieties when intercrossed; and fourthly, the imperfection of the Geological Record. In the next chapter I shall consider the geological succession of organic beings throughout time; in the eleventh and twelfth, their geographical distribution throughout space; in the thirteenth, their classification or mutual affinities, both when mature and in an embryonic condition. In the last chapter I shall give a brief recapitulation of the whole work, and a few concluding remarks.)



Charles Darwin in 1884. By Leonard Darwin - Woodall. Public Domain. Source: Wikimedia Commons.

In this somewhat long paragraph, Darwin elegantly gives the outline of his work, by enumerating the separate section of his text and explaining how they are linked to each other. Notice that he does not only announce what each section contains, he also gives a very brief summary of the content and the implications to the overall research. This is quite difficult to do, but extremely valuable. It helps the reader understand the logic of enquiry, that is, the logic connecting the arguments. In this way, the reader is invited to think WITH Darwin and to reflect on his findings from WITHIN that logic of enquiry. This is not equivalent to explaining the methodology of the research, because Darwin has not explained here what were the steps he took (the research actions), following the logic of enquiry proposed. Notice that he also promises the reader a "brief recapitulation of the whole work" in the last chapter and a "few concluding remarks". In such a monu-

mental work of analysis, recapitulating and reminding the reader about the points being made and how they are interconnected is fundamental to help the reader understand the reasoning. Notice that, although The Origin of Species is not exactly "easy reading", it is not overly complicated and the language used is relatively simple (remember it was written in the 19th century!). Darwin avoids overly complicated constructions and most insiders' jargon. Instead, he lays out a very complex line of reasoning simply and clearly, using accessible language (which is what we all ought to do!)

No one ought to feel surprise at much remaining as yet unexplained in regard to the origin of species and varieties, if he makes due allowance for our profound ignorance in regard to the mutual relations of all the beings which live around us. Who can explain why one species ranges widely and is very numerous, and why another allied species has a narrow range and is rare? Yet these relations are of the highest importance, for they determine the present welfare, and, as I believe, the future success and modification of every inhabitant of this world. Still less do we know of the mutual relations of the innumerable inhabitants of the world during the many past geological epochs in its history. Although much remains obscure, and will long remain obscure, I can entertain no doubt, after the most deliberate study and dispassionate judgement of which I am capable, that the view which most naturalists entertain, and which I formerly entertained -- namely, that each species has been independently created -- is erroneous. I am fully convinced that species are not immutable; but that those belonging to what are called the same genera are lineal descendants of some other and generally extinct species, in the same manner as the acknowledged varieties of any one species are the descendants of that species. Furthermore, I am convinced that Natural Selection has been the main but not exclusive means of modification.

Darwin is an extremely elegant writer and says that no one ought to feel surprised at how much remains unexplained, given the task at hand. He is again warning the reader that his work is not a complete, "finished" explanation on evolution, but rather an investigation using the evidence available. Much remained obscure, he wrote, and would remain obscure for a long time. But his was an effort of clarification and reasoning within a long process of knowledge formation to which he was fully aware of having contributed but a small piece. Who could explain the enormous differences in variation between different species and the next, he asks? And yet... "And yet", he writes, "these relations are of the highest importance, for they determine the present welfare, and, as I believe, the future success and modification of every inhabitant of this world". There is little doubt about the relevance of his research and the importance of his findings. Understanding evolution and adaptation was indeed crucial and had an enormous reach into how we understand who we are and our place in the world. Darwin's ideas influenced not only the scientific community, but humanity as a whole. His work presents us with crucial questions about how we live and how we deal with the word around us. Philosophically and metaphysically, it was a revolution, because it showed that through reasoning, we could attempt to explain some of the greatest mysteries that surround our existence. Not the least, the impact on the relationship between science and religion was enormous. He ends his introduction by elegantly summarizing his main theory, at which he has arrived "after the most deliberate study and dispassionate judgment" of which he was capable.

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