ON THE ORIGIN OF SPECIES

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The Science Classic

CHARLES DARWIN, M.A.

With an Introduction by
JOHN VAN WYHE

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AN INTRODUCTION

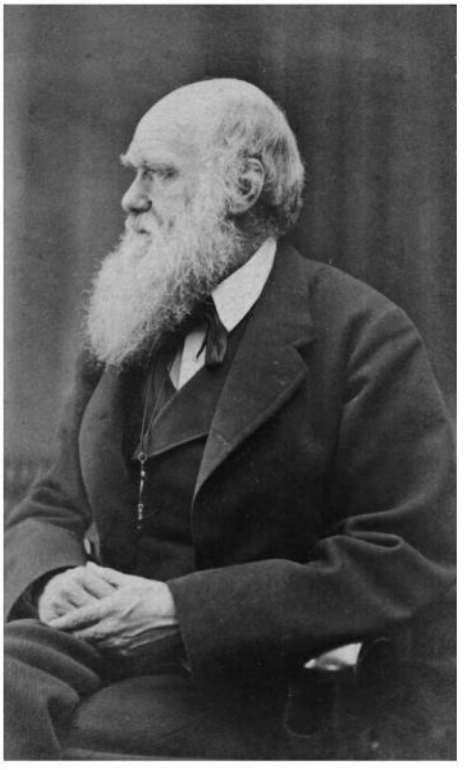
BY DR JOHN VAN WYHE

Charles Darwin transformed our understanding of life on Earth and our place in it forever. His theory of evolution by natural selection, now the unifying theory of the life sciences, explained where all of the astonishingly diverse kinds of living things came from and how they became exquisitely adapted to their particular environments and ways of life.

Darwin's theory also reconciled a host of diverse kinds of evidence such as the generally progressive fossil record, the curious geographical distribution of species, recapitulative appearances in embryos, homologous structures in different species, useless vestigial organs, and nesting taxonomic relationships. No other explanation before or since has made sense of these different classes of phenomena.

Darwin argued that species – that is the different types of organisms in the world – come not from multiple unique creation events on each island or particular place, but instead that species are the modified descendants of earlier species. He demonstrated that the source or origin of species could be entirely explained by descent from similar ancestors.

Even before Darwin entered the scientific scene, some crucial advances had been made in the study of the Earth and the fossil remains of ancient life it contains. These pre-Darwinian geologists and



palaeontologists, virtually all of them pious Christians, had discovered that the world was not a few thousand but countless millions of years old. So before Darwin ever sailed on the *Beagle* it was almost universally accepted by Western naturalists that the world was unimaginably ancient and that countless eras of life had come and gone in succession. It was also known that the fossil record was, broadly speaking, progressive. In the oldest rocks there were simple shells, then came fish with no bones like sharks, then bony fish, then amphibians, then reptiles, and finally mammals. Each era had had its own characteristic forms of plants and animals. When a species vanished from the fossil record, it never returned again. Species had gone extinct again and again.

Today, this sounds remarkably like an evolutionary understanding of the history of life on Earth. But, despite growing knowledge, the naturalists of that time were mostly extremely prejudiced against any form of evolutionary explanation. Where did they think species found in the subsequent eras came from? Initially it was believed that new species were somehow created (either supernaturally or naturally) to suit new environments. There was no real theory to make sense of the new evidence.

Darwin appeared, then, in a scientific and social context in which the pieces were in place for someone to knit them all together.

EARLY LIFE AND EDUCATION

Charles Robert Darwin (1809–82) was born the fifth of six children into a wealthy Shropshire family in the small market town of Shrewsbury. His father, Robert Waring Darwin (1766–1848), was a successful physician and financier and son of the famous poet, Erasmus Darwin (1731–1802). Charles Darwin's mother, Susannah Wedgwood (1765–1817), was the daughter of the famous potter. She died when he was eight years old. Darwin, watched over by his elder sisters and maidservants, grew up amidst wealth, comfort, and country sports. He attended the nearby Shrewsbury Grammar School as a boarder from 1818 to 1825.

In October 1825, Darwin went to Edinburgh University with his elder brother Erasmus to study medicine with a view to becoming a physician. While in Edinburgh Darwin investigated marine invertebrates with the guidance of a gentleman naturalist named Robert Grant. But it turned out that he had no inclination for medicine and could not bear the sight of blood or suffering. Darwin's father proposed the church as a respectable alternative. Although not particularly religious, the advantage to becoming a country parson, as Darwin saw it, would be the freedom to pursue his growing interest in natural history.

To become ordained in the Church of England it was necessary to first obtain a BA degree from an English university. So on 15 October

1827 he was admitted as a member of Christ's College, Cambridge. Darwin was never a model student, but he did become a passionate amateur naturalist. He began avidly collecting beetles along with fellow undergraduates, and he became the devoted follower of Professor of Botany John Stevens Henslow.

Through their close friendship Darwin learned a great deal about the practice of natural science. He passed his BA examination in January 1831. Shortly thereafter, during a tour of north Wales, he was taught the latest techniques of field geology by Professor Adam Sedgwick.

THE *BEAGLE* VOYAGE

Just at this time, Professor Henslow passed on to Darwin an alluring offer. Commander Robert FitzRoy (1805–1865) was planning a voyage on a Royal Navy survey ship, *HMS Beagle*, and was looking for a "scientific person" or naturalist.

It has become a commonplace in recent years to read that Darwin was not the official naturalist on the *Beagle* but actually the captain's companion. In fact, Darwin was officially appointed by the Admiralty, the governing body of the British Navy, to be the *Beagle*'s naturalist.

The round-the-world journey lasted five years. Darwin spent most of these years investigating the geology and zoology of the lands he visited, especially South America, the Galapagos islands, and Pacific oceanic islands. The *Beagle* eventually circumnavigated the globe, visiting New Zealand, Australia and South Africa on her return voyage.

Darwin was particularly influenced by the works of men of science like astronomer Sir John Herschel, traveller Alexander von Humboldt, and geologist Charles Lyell. Lyell's new book, *Principles of Geology* (1830–3), had a profound impact. Lyell offered not just a new view of geology but a new way of understanding nature. He showed how tiny, slow, gradual, and cumulative change over immense periods of time could produce vast changes. Lyell was seeking natural, visible, non-miraculous causes to explain natural phenomena. Darwin had the opportunity to witness all of these natural forces, such as erosion,

and early theorizing were recorded in a series of notebooks similar to those he kept during the *Beagle* voyage. These show in remarkable detail how his outlook gradually changed to reach its mature form.

In September 1838, Darwin read Thomas Malthus's *Essay on the Principle of Population* (1798). Malthus argued that human population growth, unless somehow checked, would necessarily outstrip food production. He argued that population growth was geometrical. For example, two parents might have four children, each of whom could have four children, whose children could also have four children. Thus in four generations there would be an increase from 2 to 4 to 24 to 96 and so on.

Although Malthus was an economist and social theorist, Darwin was only interested in the parts of the book that dealt with population increase in animals. Darwin's theory was not, as so often claimed, influenced by economics. Animals did not succeed in breeding geometrically if their numbers were kept in check by natural limitations such as space, food, or predators. In other examples, where checks were absent, vast population explosions or plagues resulted. He realized that an enormous proportion of living things are always destroyed before they can reproduce. This must be true because any species would otherwise breed enough to fill the entire earth in a few hundred generations. Instead, populations remain roughly stable year after year. The only way this can be so is that most offspring (from pollen to seeds and eggs) do not survive long enough to reproduce.

NATURAL SELECTION: HOW AND WHY SPECIES EVOLVE

Darwin, already concentrating on how new varieties of life might be formed, suddenly understood that the key was whatever small differences allowed some to survive long enough to reproduce, next to those that did not. He came to call this open-ended collection of causes "natural selection" because it was analogous to the way farmers and breeders selected which individuals to breed from and thus changed a breed markedly over time.

Darwin wrote in his *Autobiography* in 1876:

> *In October 1838, that is, fifteen months after I had begun my systematic enquiry, I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved, and unfavourable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work.*

All living things are slightly different, even from their closest relatives. Darwin realized that these small differences sometimes determine which creatures lived and which perished. Only the survivors could pass on their form and abilities. Their characteristics would persist and multiply whilst characteristics of those that did not live long enough to reproduce would decrease.

Darwin did not know precisely how inheritance worked – genes and DNA were totally unknown. Nevertheless, he appreciated the crucial fact of inheritance per se: offspring resemble their parents. He thought in terms of populations of diverse heritable things with no 'essence' – that is, not representatives of ideal types as many earlier thinkers had done. From his observations and experiments with domesticated and wild plants and animals he could find no limits to the extent organic forms could vary and change through generations. Thus the existing species in the world were related not along a metaphysical 'chain of being' or separated into artificially separate species categories but were all related on a genealogical family tree through "descent with modification".

Darwin also identified another means by which some individuals would have descendants and others would not. He called this sexual selection. This theory explained why the male sex in many species is larger, produces colourful displays, and has specialized body parts to attract females or to compete against other males with weapons.

Those males who defeat other males, or are selected for breeding by choosy females, leave more offspring and so subsequent generations resemble them more than those who succeed less often. As Darwin pointed out, "A hornless stag or spurless cock would have a poor chance of leaving offspring" (*Origin* p. 88).

MARRIAGE, ANNIE, AND RELIGIOUS BELIEF

In January 1839, Darwin married his cousin Emma Wedgwood (1808–96). He had deliberated about marrying, fearing it would impose on his time for scientific research. But, in a letter he wrote to Emma just before their marriage, he said: "I think you will humanize me & soon teach me there is greater happiness, than building theories, & accumulating facts in silence and solitude."

By 1842 they already had two children and were keen to withdraw from the coal smoke air pollution of London to the countryside. With some financial help from Darwin's father, they bought a large Georgian house with eighteen acres near the quiet village of Downe in Kent. Key attractions for Darwin were miles of walking paths in every direction and a "capital study". The Darwins saw it as a good place to raise a family, and for Darwin to continue his researches and write. They would make additions to the house, adding a hothouse in the garden to indulge Darwin's interest in the fertilization of orchids and to make other botanical experiments.

The Darwins would live in Down House (now a museum) for the rest of their lives. They had ten children, of whom seven survived to adulthood. Darwin's favourite daughter Anne Elizabeth, known as Annie, died tragically from disease (probably tuberculosis) in 1851. It was a "bitter and cruel loss". In recent years it has become widely believed that her death destroyed Darwin's faith in Christianity, or that he suddenly ceased attending church as a result of her death. But this is incorrect.

Darwin had "thought much upon religion" in the years 1836 to 1838 and very slowly and gradually came to disbelieve in Christianity. He found there was no evidence to support it. In his autobiography he

described this process as causing him no distress. The death of Annie, in contrast, was the most painful event of his life. While he ceased to believe in Christianity and its god, he never gave up a belief that a supernatural creator had made the universe and the laws of nature in the first place. However, like many like-minded men of his time, he was convinced that everything in nature was the result of natural laws. Thus, as far as we know, he was never an atheist.

AMASSING THE EVIDENCE

Darwin's acute and innovative books and articles had already forged for him a great reputation as a geologist, zoologist, and scientific traveller. His eight years' gruelling work cataloguing all of the world's barnacles, published 1851–4, enhanced his reputation as an authority on taxonomy as well as geology and the distribution of flora and fauna as in his earlier works.

Yet there is no evidence to allege, as is so often done, that Darwin felt he needed to supplement his reputation or skills before he could publish his species theory. Marine invertebrates had been of central interest for Darwin since his student days in Edinburgh. During the *Beagle* voyage a large proportion of his zoological notes were devoted to them, and he did not give this class of organisms to another expert to identify but kept them for himself. He consistently maintained in his letters that he would publish the theory come what may.

It is now clear that Darwin did not hold back or keep his belief in evolution a secret. The evidence from his surviving letters and notes shows that he discussed his ideas with many friends, family members, neighbours, and colleagues during the years before he published his book. Indeed, Darwin himself explicitly said so in the sixth and final edition of *Origin of Species*: "I formerly spoke to very many naturalists on the subject of evolution" (p. 424). Nor is there any foundation for the common belief that he was afraid of upsetting his religious wife. This is pure myth. She annotated his early theoretical drafts.

His full-time occupation before and long after he became an evolutionist in 1838 was the publication of his recollections and scientific

work resulting from the five-year *Beagle* voyage. This work would take him more than a decade to complete, as Professor Henslow had foretold. He conducted breeding experiments with animals and plants and corresponded and read widely for many years to refine and substantiate his theory of evolution. It took time to work out the many aspects of its implications and to solve problems with it as they arose. In 1842 he prepared a sketch outlining his theory as it then stood. This was greatly expanded in an essay written in 1844. After completing his work on barnacles, Darwin immediately turned to his theory to explain species in September 1854. By mid-1858 he was more than halfway through a large multi-volume work on the subject when he was interrupted by one of the most remarkable coincidences in the history of science.

DARWIN AND WALLACE: WHAT REALLY HAPPENED

Another Englishman, Alfred Russel Wallace (1823–1913), had been collecting specimens of animals and studying the biogeography of Southeast Asia since 1854. Wallace privately believed in some sort of evolutionary process but had never published his heterodox beliefs. But his views were at first very different from Darwin's. Wallace did not seek to explain adaptation. Instead he seems to have focused on the main feature of genealogical descent.

While staying on the remote island of Ternate in today's Indonesia, Wallace had a new idea that shifted his theories to align closely with Darwin's still unpublished views. Wallace drafted an essay to explain his new idea, drawing heavily on his reading notes and notebook speculations from the previous few years. He had independently hit on a form of natural selection to explain adaptation and species change. But when he finished it, he hesitated. Wallace was a relatively obscure collector with no prospect of a job when he returned home. And to publish a paper arguing for the then ridiculed idea of evolution was extremely risky.

When the monthly mail steamer arrived at Ternate in March 1858, Wallace received a letter of reply from his occasional correspondent,

would still need to explain how species changed and, most importantly of all, how they came to be so astonishingly adapted to their environments, and why they had immensely complex relationships with one another. Darwin's theory of natural selection explained how adaptation could occur, over many generations, given the commonly accepted but often overlooked properties of living things. The book was about how all species originate, not about the origin of any one species or the origin of life itself. Nor was it about human beings. Darwin did make it very clear, however, that humankind was part of nature. "Light will be thrown on the origin of man and his history," he writes.

THE EVOLVING *ORIGIN*

Darwin continued to revise the text of *Origin of Species* across the six British editions, and alterations were made to some of the foreign editions. In all, the British editions contain some 2250 changes in sentences (including sentences that were added and those that were removed) and more than 15,000 changes in words or phrases.

The first edition was published on 24 November 1859, the second in 1860, the third in 1861, the fourth in 1866, the fifth in 1869, and the sixth in 1872. Darwin made his final changes to the text in the printing of 1876. The third edition first carried the 2900-word "historical sketch of the recent progress of opinion on the origin of species" at the beginning. This gives a brief overview of the previous writers to offer evolutionary speculations or theories.

It was not until the fifth edition of *Origin of Species* that Darwin used the phrase "survival of the fittest". It was not even his own, having been coined by the philosopher Herbert Spencer, and adopted by Darwin at the urging of Wallace. Despite its fame, the phrase is now considered to be a very misleading shorthand for the theory. Again, perhaps surprisingly, the word "evolution" does not enter the *Origin* until a later edition: the sixth. This edition also included a new chapter to confute the views of the Roman Catholic biologist St George Mivart. It also included a "glossary of scientific terms" compiled by W. S. Dallas.

The first edition of the *Origin* is probably the best choice from the modern reader's point of view. It is the original statement of Darwin's views, and later editions became complicated as he responded to various criticisms. The text of the present volume is from the first edition of 1859 with the 'historical sketch' added from the third edition of 1861 as an Appendix. The entire text is reproduced from The Complete Work of Charles Darwin Online (http://darwin-online.org.uk/).

At the end of the first edition were pages of advertisements: "Mr. Murray's general list of works" dated June 1859 (the date differing in different copies). The adverts are omitted here.

For more detailed analyses of the *Origin* and its editions, see:

http://darwin-online.org.uk/EditorialIntroductions/Freeman_OntheOriginofSpecies.html

http://darwin-online.org.uk/EditorialIntroductions/Chancellor_vanWyhe_Origin1st.html

REACTIONS AND LEGACY

In zoology, taxonomy, botany, palaeontology, philosophy, anthropology, psychology, literature, and religion, *On the Origin of Species* provoked strong responses – many of which are ongoing. Most disturbing of all, however, were the implications for the cherished uniqueness of man. Although Darwin refrained from discussing the derivation of any particular species, including man, in the *Origin* he included – as we mentioned – the famous promissory sentence: "Much light will be thrown on the origin of man and his history".

Many people who read the book could think only about what this genealogical view of species meant for human beings. This is a subject Darwin later addressed at length in his books *The Descent of Man* (1871) and *The Expression of the Emotions in Man and Animals* (1872). In these brilliant and original works Darwin showed that there is no difference of kind between man and other animals, but only of degree. Rather than an unbridgeable gulf, Darwin showed there is a gradation of change not only between man and other animals, but between all

organic forms. This is a consequence of the gradual change continuously and cumulatively operating over time.

At first, *On the Origin of Species* was extremely controversial and some exceedingly negative reviews appeared. But Darwin's arguments and evidence were hard to resist. Remarkably, within fifteen to twenty years he was able to convince most of the international scientific community that descent with modification, or evolution, is a fact. Despite what many modern readers might encounter in popular literature or social media, the theory of evolution has not been scientifically contentious since the 1870s.

Darwin's name is so linked with evolution because the *Origin of Species* single-handedly convinced the international scientific community that evolution is a fact. As a result, Darwin became hugely famous as the man who had effected a scientific revolution with a single book. *Origin of Species* remains perhaps the most influential scientific book ever written. No other science book has been translated into more languages.

The book's final sentence remains one of the most poignant and far-reaching ever written in a scientific work:

> *There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.*

Charles Darwin

Born 12 February 1809 in Shrewsbury, England, the son of Robert Waring Darwin and Susannah, née Wedgwood.

In 1817 his mother dies. The following year he goes to Shrewsbury Free Grammar School under Samuel Butler for seven years.

In 1825 he joins his brother Erasmus at the University of Edinburgh to study medicine.

Enrols at Christ's College, University of Cambridge, in 1828. He becomes a keen entomologist and collector of beetles, and attends John Stevens Henslow's botany lectures.

Passes his BA examinations in 1831 without honours. In August returns to Shrewsbury from a trip to Wales to find a letter from Henslow inviting him to join the *Beagl*e voyage. Darwin's father objects, but his uncle, Josiah Wedgwood II, persuades him otherwise. Meets Captain Robert FitzRoy and makes preparations for the voyage. After two false starts, the ship leaves Plymouth on 27 December.

The *Beagle* lands first in the Cape Verde Islands, then surveys the east coast of South America including Tierra del Fuego and the Falkland Islands. After spending time on the east coast, the *Beagle* ventures into the Pacific, visiting Tahiti, New Zealand, and Australia. Returns to England in 1836 having traversed the Atlantic including St Helena and Ascension Island.

In 1837 Darwin moves to London and reads papers before the Geological Society of London. Begins publication of *The Zoology of the Voyage of the Beagle* (1838–43).

In 1838 he proposes marriage to Emma Wedgwood. They marry in 1839, and in the same year Darwin publishes *Journal of Researches*, later known as *Voyage of the Beagle*. Elected a Fellow of the Royal Society.

In 1842, the family settle in Down House, Kent. Darwin publishes *The Structure and Distribution of Coral Reefs*. On a visit to

Emma's family home in Staffordshire, he makes a brief pencil sketch of his developing theory of 'descent with modification'.

In 1846 publishes *Geological Observations on South America*, and begins his work on barnacles. In 1851 publishes the first of two monographs on barnacles.

On Charles Lyell's advice, in 1856 Darwin begins writing up his evolutionary views for a projected big book called 'Natural Selection'. It is later condensed into a single volume published in 1859 as *On the Origin of Species*.

In 1862 he grows his famous beard. Publishes *On the Various Contrivances by which British and Foreign Orchids are Fertilised by Insects, and On the Good Effects of Intercrossing*. Meets his friend and colleague Alfred Russel Wallace on his return from Southeast Asia.

In 1864 awarded the Copley medal of the Royal Society of London, its highest scientific honour.

In 1868 visits the Isle of Wight and meets Alfred Lord Tennyson and Julia Margaret Cameron, who photographs him.

1871 sees the publication of *The Descent of Man, and Selection in Relation to Sex*. The following year the 6th edition of *Origin of Species* is published.

In 1875 publishes *Insectivorous Plants*, and in 1876 begins an autobiographical memoir.

Dies 19 April 1882. Buried at Westminster Abbey.

ON THE ORIGIN OF SPECIES BY MEANS OF NATURAL SELECTION,

Or the Preservation of Favoured Races in the Struggle for Life

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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.

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.

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 coadaptation 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 misseltoe, 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.

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 misseltoe, 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 coadaptations 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.

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 in 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.

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 judgment 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.

hardly ever lay fertile eggs. Many exotic plants have pollen utterly worthless, in the same exact condition as in the most sterile hybrids. When, on the one hand, we see domesticated animals and plants, though often weak and sickly, yet breeding quite freely under confinement; and when, on the other hand, we see individuals, though taken young from a state of nature, perfectly tamed, long-lived, and healthy (of which I could give numerous instances), yet having their reproductive system so seriously affected by unperceived causes as to fail in acting, we need not be surprised at this system, when it does act under confinement, acting not quite regularly, and producing offspring not perfectly like their parents or variable.

Sterility has been said to be the bane of horticulture; but on this view we owe variability to the same cause which produces sterility; and variability is the source of all the choicest productions of the garden. I may add, that as some organisms will breed most freely under the most unnatural conditions (for instance, the rabbit and ferret kept in hutches), showing that their reproductive system has not been thus affected; so will some animals and plants withstand domestication or cultivation, and vary very slightly—perhaps hardly more than in a state of nature.

A long list could easily be given of "sporting plants;" by this term gardeners mean a single bud or offset, which suddenly assumes a new and sometimes very different character from that of the rest of the plant.

Such buds can be propagated by grafting, &c., and sometimes by seed. These "sports" are extremely rare under nature, but far from rare under cultivation; and in this case we see that the treatment of the parent has affected a bud or offset, and not the ovules or pollen. But it is the opinion of most physiologists that there is no essential difference between a bud and an ovule in their earliest stages of formation; so that, in fact, "sports" support my view, that variability may be largely attributed to the ovules or pollen, or to both, having been affected by the treatment of the parent prior to the act of conception. These cases anyhow show that variation is not necessarily connected, as some authors have supposed, with the act of generation.

Seedlings from the same fruit, and the young of the same litter, sometimes differ considerably from each other, though both the young and the parents, as Müller has remarked, have apparently been exposed to exactly the same conditions of life; and this shows how unimportant the direct effects of the conditions of life are in comparison with the laws of reproduction, and of growth, and of inheritance; for had the action of the conditions been direct, if any of the young had varied, all would probably have varied in the same manner. To judge how much, in the case of any variation, we should attribute to the direct action of heat, moisture, light, food, &c., is most difficult: my impression is, that with animals such agencies have produced very little direct effect, though apparently more in the case of plants. Under this point of view, Mr. Buckman's recent experiments on plants seem extremely valuable. When all or nearly all the individuals exposed to certain conditions are affected in the same way, the change at first appears to be directly due to such conditions; but in some cases it can be shown that quite opposite conditions produce similar changes of structure. Nevertheless some slight amount of change may, I think, be attributed to the direct action of the conditions of life—as, in some cases, increased size from amount of food, colour from particular kinds of food and from light, and perhaps the thickness of fur from climate.

Habit also has a decided influence, as in the period of flowering with plants when transported from one climate to another. In animals it has a more marked effect; for instance, I find in the domestic duck that the bones of the wing weigh less and the bones of the leg more, in proportion to the whole skeleton, than do the same bones in the wild-duck; and I presume that this change may be safely attributed to the domestic duck flying much less, and walking more, than its wild parent. The great and inherited development of the udders in cows and goats in countries where they are habitually milked, in comparison with the state of these organs in other countries, is another instance of the effect of use. Not a single domestic animal can be named which has not in some country drooping ears; and the view suggested by some authors, that the drooping is due

to the disuse of the muscles of the ear, from the animals not being much alarmed by danger, seems probable.

There are many laws regulating variation, some few of which can be dimly seen, and will be hereafter briefly mentioned. I will here only allude to what may be called correlation of growth. Any change in the embryo or larva will almost certainly entail changes in the mature animal. In monstrosities, the correlations between quite distinct parts are very curious; and many instances are given in Isidore Geoffroy St. Hilaire's great work on this subject. Breeders believe that long limbs are almost always accompanied by an elongated head. Some instances of correlation are quite whimsical: thus cats with blue eyes are invariably deaf; colour and constitutional peculiarities go together, of which many remarkable cases could be given amongst animals and plants. From the facts collected by Heusinger, it appears that white sheep and pigs are differently affected from coloured individuals by certain vegetable poisons. Hairless dogs have imperfect teeth; long-haired and coarse-haired animals are apt to have, as is asserted, long or many horns; pigeons with feathered feet have skin between their outer toes; pigeons with short beaks have small feet, and those with long beaks large feet. Hence, if man goes on selecting, and thus augmenting, any peculiarity, he will almost certainly unconsciously modify other parts of the structure, owing to the mysterious laws of the correlation of growth.

The result of the various, quite unknown, or dimly seen laws of variation is infinitely complex and diversified. It is well worth while carefully to study the several treatises published on some of our old cultivated plants, as on the hyacinth, potato, even the dahlia, &c.; and it is really surprising to note the endless points in structure and constitution in which the varieties and sub-varieties differ slightly from each other. The whole organisation seems to have become plastic, and tends to depart in some small degree from that of the parental type.

Any variation which is not inherited is unimportant for us. But the number and diversity of inheritable deviations of structure, both those of slight and those of considerable physiological importance,

is endless. Dr. Prosper Lucas's treatise, in two large volumes, is the fullest and the best on this subject. No breeder doubts how strong is the tendency to inheritance: like produces like is his fundamental belief: doubts have been thrown on this principle by theoretical writers alone. When a deviation appears not unfrequently, and we see it in the father and child, we cannot tell whether it may not be due to the same original cause acting on both; but when amongst individuals, apparently exposed to the same conditions, any very rare deviation, due to some extraordinary combination of circumstances, appears in the parent—say, once amongst several million individuals—and it reappears in the child, the mere doctrine of chances almost compels us to attribute its reappearance to inheritance. Every one must have heard of cases of albinism, prickly skin, hairy bodies, &c., appearing in several members of the same family. If strange and rare deviations of structure are truly inherited, less strange and commoner deviations may be freely admitted to be inheritable. Perhaps the correct way of viewing the whole subject, would be, to look at the inheritance of every character whatever as the rule, and non-inheritance as the anomaly.

The laws governing inheritance are quite unknown; no one can say why the same peculiarity in different individuals of the same species, and in individuals of different species, is sometimes inherited and sometimes not so; why the child often reverts in certain characters to its grandfather or grandmother or other much more remote ancestor; why a peculiarity is often transmitted from one sex to both sexes, or to one sex alone, more commonly but not exclusively to the like sex. It is a fact of some little importance to us, that peculiarities appearing in the males of our domestic breeds are often transmitted either exclusively, or in a much greater degree, to males alone. A much more important rule, which I think may be trusted, is that, at whatever period of life a peculiarity first appears, it tends to appear in the offspring at a corresponding age, though sometimes earlier. In many cases this could not be otherwise: thus the inherited peculiarities in the horns of cattle could appear only in the offspring when nearly mature; peculiarities in the silkworm are known to appear at

the corresponding caterpillar or cocoon stage. But hereditary diseases and some other facts make me believe that the rule has a wider extension, and that when there is no apparent reason why a peculiarity should appear at any particular age, yet that it does tend to appear in the offspring at the same period at which it first appeared in the parent. I believe this rule to be of the highest importance in explaining the laws of embryology. These remarks are of course confined to the first *appearance* of the peculiarity, and not to its primary cause, which may have acted on the ovules or male element; in nearly the same manner as in the crossed offspring from a short-horned cow by a long-horned bull, the greater length of horn, though appearing late in life, is clearly due to the male element.

Having alluded to the subject of reversion, I may here refer to a statement often made by naturalists—namely, that our domestic varieties, when run wild, gradually but certainly revert in character to their aboriginal stocks. Hence it has been argued that no deductions can be drawn from domestic races to species in a state of nature. I have in vain endeavoured to discover on what decisive facts the above statement has so often and so boldly been made. There would be great difficulty in proving its truth: we may safely conclude that very many of the most strongly-marked domestic varieties could not possibly live in a wild state. In many cases we do not know what the aboriginal stock was, and so could not tell whether or not nearly perfect reversion had ensued. It would be quite necessary, in order to prevent the effects of intercrossing, that only a single variety should be turned loose in its new home. Nevertheless, as our varieties certainly do occasionally revert in some of their characters to ancestral forms, it seems to me not improbable, that if we could succeed in naturalising, or were to cultivate, during many generations, the several races, for instance, of the cabbage, in very poor soil (in which case, however, some effect would have to be attributed to the direct action of the poor soil), that they would to a large extent, or even wholly, revert to the wild aboriginal stock. Whether or not the experiment would succeed, is not of great importance for our line of argument; for by the experiment itself the conditions of life are changed. If it

average as largely as the parent species of our existing domesticated productions have varied.

In the case of most of our anciently domesticated animals and plants, I do not think it is possible to come to any definite conclusion, whether they have descended from one or several species. The argument mainly relied on by those who believe in the multiple origin of our domestic animals is, that we find in the most ancient records, more especially on the monuments of Egypt, much diversity in the breeds; and that some of the breeds closely resemble, perhaps are identical with, those still existing. Even if this latter fact were found more strictly and generally true than seems to me to be the case, what does it show, but that some of our breeds originated there, four or five thousand years ago? But Mr. Horner's researches have rendered it in some degree probable that man sufficiently civilized to have manufactured pottery existed in the valley of the Nile thirteen or fourteen thousand years ago; and who will pretend to say how long before these ancient periods, savages, like those of Tierra del Fuego or Australia, who possess a semi-domestic dog, may not have existed in Egypt?

The whole subject must, I think, remain vague; neverthelsss, I may, without here entering on any details, state that, from geographical and other considerations, I think it highly probable that our domestic dogs have descended from several wild species. In regard to sheep and goats I can form no opinion. I should think, from facts communicated to me by Mr. Blyth, on the habits, voice, and constitution, &c., of the humped Indian cattle, that these had descended from a different aboriginal stock from our European cattle; and several competent judges believe that these latter have had more than one wild parent. With respect to horses, from reasons which I cannot give here, I am doubtfully inclined to believe, in opposition to several authors, that all the races have descended from one wild stock. Mr. Blyth, whose opinion, from his large and varied stores of knowledge, I should value more than that of almost any one, thinks that all the breeds of poultry have proceeded from the common wild Indian fowl (Gallus bankiva). In regard to ducks and rabbits, the breeds of which

differ considerably from each other in structure, I do not doubt that they all have descended from the common wild duck and rabbit.

The doctrine of the origin of our several domestic races from several aboriginal stocks, has been carried to an absurd extreme by some authors. They believe that every race which breeds true, let the distinctive characters be ever so slight, has had its wild prototype. At this rate there must have existed at least a score of species of wild cattle, as many sheep, and several goats in Europe alone, and several even within Great Britain. One author believes that there formerly existed in Great Britain eleven wild species of sheep peculiar to it! When we bear in mind that Britain has now hardly one peculiar mammal, and France but few distinct from those of Germany and conversely, and so with Hungary, Spain, &c., but that each of these kingdoms possesses several peculiar breeds of cattle, sheep, &c., we must admit that many domestic breeds have originated in Europe; for whence could they have been derived, as these several countries do not possess a number of peculiar species as distinct parent-stocks? So it is in India. Even in the case of the domestic dogs of the whole world, which I fully admit have probably descended from several wild species, I cannot doubt that there has been an immense amount of inherited variation. Who can believe that animals closely resembling the Italian greyhound, the bloodhound, the bull-dog, or Blenheim spaniel, &c.—so unlike all wild Canidæ—ever existed freely in a state of nature? It has often been loosely said that all our races of dogs have been produced by the crossing of a few aboriginal species; but by crossing we can get only forms in some degree intermediate between their parents; and if we account for our several domestic races by this process, we must admit the former existence of the most extreme forms, as the Italian greyhound, bloodhound, bull-dog, &c., in the wild state. Moreover, the possibility of making distinct races by crossing has been greatly exaggerated. There can be no doubt that a race may be modified by occasional crosses, if aided by the careful selection of those individual mongrels, which present any desired character; but that a race could be obtained nearly intermediate between two extremely different races or species, I can hardly believe.

Sir J. Sebright expressly experimentised for this object, and failed. The offspring from the first cross between two pure breeds is tolerably and sometimes (as I have found with pigeons) extremely uniform, and everything seems simple enough; but when these mongrels are crossed one with another for several generations, hardly two of them will be alike, and then the extreme difficulty, or rather utter hopelessness, of the task becomes apparent. Certainly, a breed intermediate between *two very distinct* breeds could not be got without extreme care and long-continued selection; nor can I find a single case on record of a permanent race having been thus formed.

On the Breeds of the Domestic Pigeon.—Believing that it is always best to study some special group, I have, after deliberation, taken up domestic pigeons. I have kept every breed which I could purchase or obtain, and have been most kindly favoured with skins from several quarters of the world, more especially by the Hon. W. Elliot from India, and by the Hon. C. Murray from Persia. Many treatises in different languages have been published on pigeons, and some of them are very important, as being of considerable antiquity. I have associated with several eminent fanciers, and have been permitted to join two of the London Pigeon Clubs. The diversity of the breeds is something astonishing. Compare the English carrier and the short-faced tumbler, and see the wonderful difference in their beaks, entailing corresponding differences in their skulls. The carrier, more especially the male bird, is also remarkable from the wonderful development of the carunculated skin about the head, and this is accompanied by greatly elongated eyelids, very large external orifices to the nostrils, and a wide gape of mouth. The short-faced tumbler has a beak in outline almost like that of a finch; and the common tumbler has the singular and strictly inherited habit of flying at a great height in a compact flock, and tumbling in the air head over heels. The runt is a bird of great size, with long, massive beak and large feet; some of the sub-breeds of runts have very long necks, others very long wings and tails, others singularly short tails. The barb is allied to the carrier, but, instead of a very long beak, has a very short and very broad one. The pouter has a much elongated body, wings, and

legs; and its enormously developed crop, which it glories in inflating, may well excite astonishment and even laughter. The turbit has a very short and conical beak, with a line of reversed feathers down the breast; and it has the habit of continually expanding slightly the upper part of the œsophagus. The Jacobin has the feathers so much reversed along the back of the neck that they form a hood, and it has, proportionally to its size, much elongated wing and tail feathers. The trumpeter and laugher, as their names express, utter a very different coo from the other breeds. The fantail has thirty or even forty tail-feathers, instead of twelve or fourteen, the normal number in all members of the great pigeon family; and these feathers are kept expanded, and are carried so erect that in good birds the head and tail touch; the oil-gland is quite aborted. Several other less distinct breeds might have been specified.

In the skeletons of the several breeds, the development of the bones of the face in length and breadth and curvature differs enormously. The shape, as well as the breadth and length of the ramus of the lower jaw, varies in a highly remarkable manner. The number of the caudal and sacral vertebræ vary; as does the number of the ribs, together with their relative breadth and the presence of processes. The size and shape of the apertures in the sternum are highly variable; so is the degree of divergence and relative size of the two arms of the furcula. The proportional width of the gape of mouth, the proportional length of the eyelids, of the orifice of the nostrils, of the tongue (not always in strict correlation with the length of beak), the size of the crop and of the upper part of the œsophagus; the development and abortion of the oil-gland; the number of the primary wing and caudal feathers; the relative length of wing and tail to each other and to the body; the relative length of leg and of the feet; the number of scutellæ on the toes, the development of skin between the toes, are all points of structure which are variable. The period at which the perfect plumage is acquired varies, as does the state of the down with which the nestling birds are clothed when hatched. The shape and size of the eggs vary. The manner of flight differs remarkably; as does in some breeds the voice and disposition.

Lastly, in certain breeds, the males and females have come to differ to a slight degree from each other.

Altogether at least a score of pigeons might be chosen, which if shown to an ornithologist, and he were told that they were wild birds, would certainly, I think, be ranked by him as well-defined species. Moreover, I do not believe that any ornithologist would place the English carrier, the short-faced tumbler, the runt, the barb, pouter, and fantail in the same genus; more especially as in each of these breeds several truly-inherited sub-breeds, or species as he might have called them, could be shown him.

Great as the differences are between the breeds of pigeons, I am fully convinced that the common opinion of naturalists is correct, namely, that all have descended from the rock-pigeon (Columba livia), including under this term several geographical races or sub-species, which differ from each other in the most trifling respects. As several of the reasons which have led me to this belief are in some degree applicable in other cases, I will here briefly give them. If the several breeds are not varieties, and have not proceeded from the rock-pigeon, they must have descended from at least seven or eight aboriginal stocks; for it is impossible to make the present domestic breeds by the crossing of any lesser number: how, for instance, could a pouter be produced by crossing two breeds unless one of the parent-stocks possessed the characteristic enormous crop? The supposed aboriginal stocks must all have been rock-pigeons, that is, not breeding or willingly perching on trees. But besides C. livia, with its geographical sub-species, only two or three other species of rock-pigeons are known; and these have not any of the characters of the domestic breeds. Hence the supposed aboriginal stocks must either still exist in the countries where they were originally domesticated, and yet be unknown to ornithologists; and this, considering their size, habits, and remarkable characters, seems very improbable; or they must have become extinct in the wild state. But birds breeding on precipices, and good fliers, are unlikely to be exterminated; and the common rock-pigeon, which has the same habits with the domestic breeds, has not been exterminated even on several of the smaller

indefinite number of generations. These two distinct cases are often confounded in treatises on inheritance.

Lastly, the hybrids or mongrels from between all the domestic breeds of pigeons are perfectly fertile. I can state this from my own observations, purposely made on the most distinct breeds. Now, it is difficult, perhaps impossible, to bring forward one case of the hybrid offspring of two animals *clearly distinct* being themselves perfectly fertile. Some authors believe that long-continued domestication eliminates this strong tendency to sterility: from the history of the dog I think there is some probability in this hypothesis, if applied to species closely related together, though it is unsupported by a single experiment. But to extend the hypothesis so far as to suppose that species, aboriginally as distinct as carriers, tumblers, pouters, and fantails now are, should yield offspring perfectly fertile, *inter se*, seems to me rash in the extreme.

From these several reasons, namely, the improbability of man having formerly got seven or eight supposed species of pigeons to breed freely under domestication; these supposed species being quite unknown in a wild state, and their becoming nowhere feral; these species having very abnormal characters in certain respects, as compared with all other Columbidæ, though so like in most other respects to the rock-pigeon; the blue colour and various marks occasionally appearing in all the breeds, both when kept pure and when crossed; the mongrel offspring being perfectly fertile;—from these several reasons, taken together, I can feel no doubt that all our domestic breeds have descended from the Columba livia with its geographical sub-species.

In favour of this view, I may add, firstly, that C. livia, or the rock-pigeon, has been found capable of domestication in Europe and in India; and that it agrees in habits and in a great number of points of structure with all the domestic breeds. Secondly, although an English carrier or short-faced tumbler differs immensely in certain characters from the rock-pigeon, yet by comparing the several sub-breeds of these breeds, more especially those brought from distant countries,

we can make an almost perfect series between the extremes of structure. Thirdly, those characters which are mainly distinctive of each breed, for instance the wattle and length of beak of the carrier, the shortness of that of the tumbler, and the number of tail-feathers in the fantail, are in each breed eminently variable; and the explanation of this fact will be obvious when we come to treat of selection. Fourthly, pigeons have been watched, and tended with the utmost care, and loved by many people. They have been domesticated for thousands of years in several quarters of the world; the earliest known record of pigeons is in the fifth Ægyptian dynasty, about 3000 B.C., as was pointed out to me by Professor Lepsius; but Mr. Birch informs me that pigeons are given in a bill of fare in the previous dynasty. In the time of the Romans, as we hear from Pliny, immense prices were given for pigeons; "nay, they are come to this pass, that they can reckon up their pedigree and race." Pigeons were much valued by Akber Khan in India, about the year 1600; never less than 20,000 pigeons were taken with the court. "The monarchs of Iran and Turan sent him some very rare birds;" and, continues the courtly historian, "His Majesty by crossing the breeds, which method was never practised before, has improved them astonishingly." About this same period the Dutch were as eager about pigeons as were the old Romans. The paramount importance of these considerations in explaining the immense amount of variation which pigeons have undergone, will be obvious when we treat of Selection. We shall then, also, see how it is that the breeds so often have a somewhat monstrous character. It is also a most favourable circumstance for the production of distinct breeds, that male and female pigeons can be easily mated for life; and thus different breeds can be kept together in the same aviary.

I have discussed the probable origin of domestic pigeons at some, yet quite insufficient, length; because when I first kept pigeons and watched the several kinds, knowing well how true they bred, I felt fully as much difficulty in believing that they could ever have descended from a common parent, as any naturalist could in coming to a similar conclusion in regard to the many species of finches, or

other large groups of birds, in nature. One circumstance has struck me much; namely, that all the breeders of the various domestic animals and the cultivators of plants, with whom I have ever conversed, or whose treatises I have read, are firmly convinced that the several breeds to which each has attended, are descended from so many aboriginally distinct species.

Ask, as I have asked, a celebrated raiser of Hereford cattle, whether his cattle might not have descended from long-horns, and he will laugh you to scorn. I have never met a pigeon, or poultry, or duck, or rabbit fancier, who was not fully convinced that each main breed was descended from a distinct species. Van Mons, in his treatise on pears and apples, shows how utterly he disbelieves that the several sorts, for instance a Ribston-pippin or Codlin-apple, could ever have proceeded from the seeds of the same tree. Innumerable other examples could be given. The explanation, I think, is simple: from long-continued study they are strongly impressed with the differences between the several races; and though they well know that each race varies slightly, for they win their prizes by selecting such slight differences, yet they ignore all general arguments, and refuse to sum up in their minds slight differences accumulated during many successive generations. May not those naturalists who, knowing far less of the laws of inheritance than does the breeder, and knowing no more than he does of the intermediate links in the long lines of descent, yet admit that many of our domestic races have descended from the same parents—may they not learn a lesson of caution, when they deride the idea of species in a state of nature being lineal descendants of other species?

Selection. —Let us now briefly consider the steps by which domestic races have been produced, either from one or from several allied species. Some little effect may, perhaps, be attributed to the direct action of the external conditions of life, and some little to habit; but he would be a bold man who would account by such agencies for the differences of a dray and race horse, a greyhound and bloodhound, a carrier and tumbler pigeon. One of the most remarkable features in our domesticated races is that we see in them adaptation,

not indeed to the animal's or plant's own good, but to man's use or fancy. Some variations useful to him have probably arisen suddenly, or by one step; many botanists, for instance, believe that the fuller's teazle, with its hooks, which cannot be rivalled by any mechanical contrivance, is only a variety of the wild Dipsacus; and this amount of change may have suddenly arisen in a seedling. So it has probably been with the turnspit dog; and this is known to have been the case with the ancon sheep. But when we compare the dray-horse and race-horse, the dromedary and camel, the various breeds of sheep fitted either for cultivated land or mountain pasture, with the wool of one breed good for one purpose, and that of another breed for another purpose; when we compare the many breeds of dogs, each good for man in very different ways; when we compare the game-cock, so pertinacious in battle, with other breeds so little quarrelsome, with "everlasting layers" which never desire to sit, and with the bantam so small and elegant; when we compare the host of agricultural, culinary, orchard, and flower-garden races of plants, most useful to man at different seasons and for different purposes, or so beautiful in his eyes, we must, I think, look further than to mere variability. We cannot suppose that all the breeds were suddenly produced as perfect and as useful as we now see them; indeed, in several cases, we know that this has not been their history. The key is man's power of accumulative selection: nature gives successive variations; man adds them up in certain directions useful to him. In this sense he may be said to make for himself useful breeds.

The great power of this principle of selection is not hypothetical. It is certain that several of our eminent breeders have, even within a single lifetime, modified to a large extent some breeds of cattle and sheep. In order fully to realise what they have done, it is almost necessary to read several of the many treatises devoted to this subject, and to inspect the animals. Breeders habitually speak of an animal's organisation as something quite plastic, which they can model almost as they please. If I had space I could quote numerous passages to this effect from highly competent authorities. Youatt, who was probably better acquainted with the works of agriculturalists than almost any

other individual, and who was himself a very good judge of an animal, speaks of the principle of selection as "that which enables the agriculturist, not only to modify the character of his flock, but to change it altogether. It is the magician's wand, by means of which he may summon into life whatever form and mould he pleases." Lord Somerville, speaking of what breeders have done for sheep, says:—"It would seem as if they had chalked out upon a wall a form perfect in itself, and then had given it existence." That most skilful breeder, Sir John Sebright, used to say, with respect to pigeons, that "he would produce any given feather in three years, but it would take him six years to obtain head and beak." In Saxony the importance of the principle of selection in regard to merino sheep is so fully recognised, that men follow it as a trade: the sheep are placed on a table and are studied, like a picture by a connoisseur; this is done three times at intervals of months, and the sheep are each time marked and classed, so that the very best may ultimately be selected for breeding.

What English breeders have actually effected is proved by the enormous prices given for animals with a good pedigree; and these have now been exported to almost every quarter of the world. The improvement is by no means generally due to crossing different breeds; all the best breeders are strongly opposed to this practice, except sometimes amongst closely allied sub-breeds. And when a cross has been made, the closest selection is far more indispensable even than in ordinary cases. If selection consisted merely in separating some very distinct variety, and breeding from it, the principle would be so obvious as hardly to be worth notice; but its importance consists in the great effect produced by the accumulation in one direction, during successive generations, of differences absolutely inappreciable by an uneducated eye—differences which I for one have vainly attempted to appreciate. Not one man in a thousand has accuracy of eye and judgment sufficient to become an eminent breeder. If gifted with these qualities, and he studies his subject for years, and devotes his lifetime to it with indomitable perseverance, he will succeed, and may make great improvements; if he wants any of these qualities, he will assuredly fail. Few would readily believe in

of permanently altering the breed. Nevertheless I cannot doubt that this process, continued during centuries, would improve and modify any breed, in the same way as Bakewell, Collins, &c., by this very same process, only carried on more methodically, did greatly modify, even during their own lifetimes, the forms and qualities of their cattle. Slow and insensible changes of this kind could never be recognised unless actual measurements or careful drawings of the breeds in question had been made long ago, which might serve for comparison. In some cases, however, unchanged or but little changed individuals of the same breed may be found in less civilised districts, where the breed has been less improved. There is reason to believe that King Charles's spaniel has been unconsciously modified to a large extent since the time of that monarch. Some highly competent authorities are convinced that the setter is directly derived from the spaniel, and has probably been slowly altered from it. It is known that the English pointer has been greatly changed within the last century, and in this case the change has, it is believed, been chiefly effected by crosses with the fox-hound; but what concerns us is, that the change has been effected unconsciously and gradually, and yet so effectually, that, though the old Spanish pointer certainly came from Spain, Mr. Borrow has not seen, as I am informed by him, any native dog in Spain like our pointer.

By a similar process of selection, and by careful training, the whole body of English racehorses have come to surpass in fleetness and size the parent Arab stock, so that the latter, by the regulations for the Goodwood Races, are favoured in the weights they carry. Lord Spencer and others have shown how the cattle of England have increased in weight and in early maturity, compared with the stock formerly kept in this country. By comparing the accounts given in old pigeon treatises of carriers and tumblers with these breeds as now existing in Britain, India, and Persia, we can, I think, clearly trace the stages through which they have insensibly passed, and come to differ so greatly from the rock-pigeon.

Youatt gives an excellent illustration of the effects of a course of selection, which may be considered as unconsciously followed,

in so far that the breeders could never have expected or even have wished to have produced the result which ensued—namely, the production of two distinct strains. The two flocks of Leicester sheep kept by Mr. Buckley and Mr. Burgess, as Mr. Youatt remarks, "have been purely bred from the original stock of Mr. Bakewell for upwards of fifty years. There is not a suspicion existing in the mind of any one at all acquainted with the subject that the owner of either of them has deviated in any one instance from the pure blood of Mr. Bakewell's flock, and yet the difference between the sheep possessed by these two gentlemen is so great that they have the appearance of being quite different varieties."

If there exist savages so barbarous as never to think of the inherited character of the offspring of their domestic animals, yet any one animal particularly useful to them, for any special purpose, would be carefully preserved during famines and other accidents, to which savages are so liable, and such choice animals would thus generally leave more offspring than the inferior ones; so that in this case there would be a kind of unconscious selection going on. We see the value set on animals even by the barbarians of Tierra del Fuego, by their killing and devouring their old women, in times of dearth, as of less value than their dogs.

In plants the same gradual process of improvement, through the occasional preservation of the best individuals, whether or not sufficiently distinct to be ranked at their first appearance as distinct varieties, and whether or not two or more species or races have become blended together by crossing, may plainly be recognised in the increased size and beauty which we now see in the varieties of the heartsease, rose, pelargonium, dahlia, and other plants, when compared with the older varieties or with their parent-stocks. No one would ever expect to get a first-rate heartsease or dahlia from the seed of a wild plant. No one would expect to raise a first-rate melting pear from the seed of the wild pear, though he might succeed from a poor seedling growing wild, if it had come from a garden-stock. The pear, though cultivated in classical times, appears, from Pliny's description, to have been a fruit of very inferior quality. I have seen

great surprise expressed in horticultural works at the wonderful skill of gardeners, in having produced such splendid results from such poor materials; but the art, I cannot doubt, has been simple, and, as far as the final result is concerned, has been followed almost unconsciously. It has consisted in always cultivating the best known variety, sowing its seeds, and, when a slightly better variety has chanced to appear, selecting it, and so onwards. But the gardeners of the classical period, who cultivated the best pear they could procure, never thought what splendid fruit we should eat; though we owe our excellent fruit, in some small degree, to their having naturally chosen and preserved the best varieties they could anywhere find.

A large amount of change in our cultivated plants, thus slowly and unconsciously accumulated, explains, as I believe, the well-known fact, that in a vast number of cases we cannot recognise, and therefore do not know, the wild parent-stocks of the plants which have been longest cultivated in our flower and kitchen gardens. If it has taken centuries or thousands of years to improve or modify most of our plants up to their present standard of usefulness to man, we can understand how it is that neither Australia, the Cape of Good Hope, nor any other region inhabited by quite uncivilised man, has afforded us a single plant worth culture. It is not that these countries, so rich in species, do not by a strange chance possess the aboriginal stocks of any useful plants, but that the native plants have not been improved by continued selection up to a standard of perfection comparable with that given to the plants in countries anciently civilised.

In regard to the domestic animals kept by uncivilised man, it should not be overlooked that they almost always have to struggle for their own food, at least during certain seasons. And in two countries very differently circumstanced, individuals of the same species, having slightly different constitutions or structure, would often succeed better in the one country than in the other, and thus by a process of "natural selection," as will hereafter be more fully explained, two sub-breeds might be formed. This, perhaps, partly explains what has been remarked by some authors, namely, that the varieties kept by

savages have more of the character of species than the varieties kept in civilised countries.

On the view here given of the all-important part which selection by man has played, it becomes at once obvious, how it is that our domestic races show adaptation in their structure or in their habits to man's wants or fancies. We can, I think, further understand the frequently abnormal character of our domestic races, and likewise their differences being so great in external characters and relatively so slight in internal parts or organs. Man can hardly select, or only with much difficulty, any deviation of structure excepting such as is externally visible; and indeed he rarely cares for what is internal. He can never act by selection, excepting on variations which are first given to him in some slight degree by nature. No man would ever try to make a fantail, till he saw a pigeon with a tail developed in some slight degree in an unusual manner, or a pouter till he saw a pigeon with a crop of somewhat unusual size; and the more abnormal or unusual any character was when it first appeared, the more likely it would be to catch his attention. But to use such an expression as trying to make a fantail, is, I have no doubt, in most cases, utterly incorrect. The man who first selected a pigeon with a slightly larger tail, never dreamed what the descendants of that pigeon would become through long-continued, partly unconscious and partly methodical selection. Perhaps the parent bird of all fantails had only fourteen tail-feathers somewhat expanded, like the present Java fantail, or like individuals of other and distinct breeds, in which as many as seventeen tail-feathers have been counted. Perhaps the first pouter-pigeon did not inflate its crop much more than the turbit now does the upper part of its œsophagus,—a habit which is disregarded by all fanciers, as it is not one of the points of the breed.

Nor let it be thought that some great deviation of structure would be necessary to catch the fancier's eye: he perceives extremely small differences, and it is in human nature to value any novelty, however slight, in one's own possession. Nor must the value which would formerly be set on any slight differences in the individuals of the same species, be judged of by the value which would now be set on them,

after several breeds have once fairly been established. Many slight differences might, and indeed do now, arise amongst pigeons, which are rejected as faults or deviations from the standard of perfection of each breed. The common goose has not given rise to any marked varieties; hence the Thoulouse and the common breed, which differ only in colour, that most fleeting of characters, have lately been exhibited as distinct at our poultry-shows.

I think these views further explain what has sometimes been noticed—namely that we know nothing about the origin or history of any of our domestic breeds. But, in fact, a breed, like a dialect of a language, can hardly be said to have had a definite origin. A man preserves and breeds from an individual with some slight deviation of structure, or takes more care than usual in matching his best animals and thus improves them, and the improved individuals slowly spread in the immediate neighbourhood. But as yet they will hardly have a distinct name, and from being only slightly valued, their history will be disregarded. When further improved by the same slow and gradual process, they will spread more widely, and will get recognised as something distinct and valuable, and will then probably first receive a provincial name. In semi-civilised countries, with little free communication, the spreading and knowledge of any new sub-breed will be a slow process. As soon as the points of value of the new sub-breed are once fully acknowledged, the principle, as I have called it, of unconscious selection will always tend,—perhaps more at one period than at another, as the breed rises or falls in fashion,—perhaps more in one district than in another, according to the state of civilisation of the inhabitants,—slowly to add to the characteristic features of the breed, whatever they may be. But the chance will be infinitely small of any record having been preserved of such slow, varying, and insensible changes.

I must now say a few words on the circumstances, favourable, or the reverse, to man's power of selection. A high degree of variability is obviously favourable, as freely giving the materials for selection to work on; not that mere individual differences are not amply sufficient, with extreme care, to allow of the accumulation of a large