THE GREAT VICTORIANS

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HUGH MASSINGHAM

The editors have endeavored to enlist the most representative company of the moderns so that the mind of our own age might gaze back upon the towering figures of the age it has left behind.

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CHARLES ROBERT DARWIN

1809–1882

G. P. Wells

Some are born great, some achieve greatness, and some have greatness thrust upon them." It is hard to tell to which of these categories Charles Darwin should be assigned. He was certainly not born into the limelight. He came into it with dramatic abruptness, but belatedly. For the first fifty years of his life he was a little-known man, except to a small circle of his professional colleagues, and throughout that period he produced nothing to merit a wider recognition. He was sent to Edinburgh at the age of sixteen to study medicine; soon, being obviously unfitted for that profession, he was removed to Cambridge to become a clergyman. At the latter university he divided his energy between hunting, shooting, and the industrious collection of beetles, and his clerical ambitions (or rather his father's), to quote his own words, "died a natural death." Immediately after graduating, he joined the staff of a research ship, the *Beagle*, in which he sailed about the world for five years. Returning with his collections from this adventure, he went at first to London, where for a while he was Secretary of the Geological Society, and where he married; at thirty-three, already broken down in health, he retired for the rest of his life to a country house at Down, in Kent.

> "During the first part of our residence [he wrote of this phase], we went a little into society, and received a few friends here; but my health almost always suffered from the excitement, violent shivering and vomiting attacks being thus brought on. I have therefore been compelled for many years to give up all dinner-parties. . . ."

Happily, being the son of a prosperous and affectionate country doctor, he had no need to work for a living. From thirty-seven to forty-five he devoted himself to the preparation of an exhaustive monograph on recent and fossil barnacles.

Suddenly, at fifty, this invalid naturalist became famous. In the *Origin of Species by Means of Natural Selection*, he put forward an idea which he had been unobtrusively incubating for twenty years. The success of this book was immediate and astounding. His publishers were quite unprepared for the reception it received: a small first edition of 1,250 copies was exhausted on the day of publication, and the second did not appear until two months afterwards. In a very few years, the *Origin of Species* had brought about a revolution in the whole framework of contemporary philosophy. It had been translated into almost every European tongue, and even into Japanese. An essay in Hebrew had appeared, which proved that its theory was contained in the Old Testament.

To understand this eager reception, we must consider for a moment the state of mind of the world into which the book was published.

Before the latter half of the nineteenth century it was generally believed that the species of animals and plants were fixed and immutable. God created them in 4004 B.C. His handiwork had persisted unaltered since that date, having been saved by Noah from untimely destruction, and it would continue to persist until He saw fit to revise it in the very thorough manner described in the Book of Revelation.

But the crust of the earth was teeming with eloquent witnesses against this belief. Scattered through the rocks were the fossilized remains of animals and plants. The significance of their testimony was long obscured by the interpretations they received. Aristotle declared that they had germinated spontaneously where they were found, and when, in the seventeenth century, the unquestioning faith with which his writings had been accepted waned, and this view was discarded, it was replaced by another false explanation. Most of these fossils were of marine creatures, preserved by the fine sediments that slowly collect on the sea floor, so their occurrence in the rocks of large land masses, far from any sea, was attributed to the Deluge. In

this way, the fossils became proofs of the literal truth of Genesis. But as the collection and study of fossils progressed, this theory in turn became untenable.

In addition to the fossils, a host of other puzzling facts awaited the evolutionary interpretation. There were manifest imperfections in the structure of many creatures—such as the useless little vestigial leg bones embedded in the belly of a whale—which suggested that creation, if it had occurred, had been, to say the least, uneconomical; and there were odd resemblances between animals of different kinds, and points about the geographical distribution of animal and plant species that were hard to reconcile with the generally accepted story of the origin of the world.

As these facts accumulated, a number of naturalists came to question the immutability of species; and here and there, more or less explicitly, the idea that a species may slowly change into something quite different began to appear in scientific writings.

When Darwin began his studies, at Edinburgh and at Cambridge, the immutability of species was still the generally held doctrine, even among biologists, although the rival view had already been put forward.

> "It has sometimes been said [he wrote in a later retrospect] that the success of the *Origin of Species* proved that 'the subject was in the air,' or 'that men's minds were prepared for it.' I do not think that this is strictly true, for I occasionally sounded not a few naturalists, and never happened to come across a single one who seemed to doubt about the permanence of species."

And when, after long thought, Darwin first confessed his evolutionary suspicions in a letter to Sir John Hooker, he expressed himself as follows: "I am almost convinced that species are not (it is like confessing a murder) immutable." Nevertheless, although the majority of biologists were still creationists when the *Origin of Species* was published, the evolutionary idea had been vigorously expounded by the Comte de Buffon, by Darwin's own grandfather Erasmus, by Lamarck, by Saint-

Hilaire, by Treviranus, and less conspicuously by a number of other authors.

One of these pre-Darwinian evolutionists is of peculiar interest. In 1813, a Dr. W. C. Wells read before the Royal Society, and subsequently published, *An Account of a White Female, part of whose skin resembles that of a Negro.* This essay contains a clear description, not only of the gradual modification of a race, but of Darwin's own hypothesis of Natural Selection. Dr. Wells discusses the fact that negroes and mulattoes are better adapted than white men to live in hot climates. To explain their fitness, he points out that all animals tend to vary slightly from each other, and that breeders steadily improve the races of domesticated animals by picking out the most suitable variations to breed from. What the breeder does

> "by art, seems to be done with equal efficacy, though more slowly, by Nature, in the formation of varieties of mankind, fitted for the country in which they inhabit. Of the accidental varieties of man, which would occur among the first few and scattered inhabitants of the middle regions of Africa, some one would be better fitted than the others to bear the diseases of the country. This race would consequently multiply, while the others would decrease; not only from their inability to sustain attacks of disease, but from their incapacity of contending with their more vigorous neighbours. The colour of this vigorous race I take for granted, from what has already been said, would be dark. But the same disposition to form varieties still existing, a darker and darker race would in course of time occur; and as the darkest would be the best fitted for the climate, this would at length become the most prevalent, if not the only race."

The white woman, part of whose skin resembled that of a negro, was of course an example of the kind of variation upon which the selective process could act. This very remarkable essay was published when Darwin was nine years old, but it attracted little attention, and did not come to Darwin's notice until after the appearance of the *Origin of Species.*

The biologists, then, had before them a mass of evidence for evolution, and a number of expositions of the theory, but, with rare exceptions, they still believed in the fixity of species. It is curious to note how they were made to change their belief.

Darwin's own conversion was characteristically slow. He was by nature a cautious man. He collected and sorted relevant facts for more than twenty years before he published the *Origin of Species*. Herein lies one reason for the enthusiasm with which his work was received. It is a thoroughly documented book. In this it differs from the writings of his predecessors. Buffon was an attractive writer, and a brilliant sweeping thinker, but not a painstaking collector of evidence. Lamarck wrote heavily and with difficulty, and lapsed often into unprofitable speculation. Huxley lamented with good reason that the theory of evolution had been "sadly damaged by some of its supporters."

But much more important than this in determining its success is the fact that the *Origin of Species* contains two entirely different ideas. It presents evidence for believing that evolution has occurred, and it also presents a mechanism by which evolution can be explained—the hypothesis of Natural Selection.

We have already traced the main features of that hypothesis in an extract from a paper by Dr. Wells. Darwin applied it, not only to the adaptation of human races to the regions in which they live, but to the whole spectacle of organic evolution. In all organisms, without exception, the number of young produced is far greater than can possibly grow to maturity and reproduce their kind. There is, therefore, in every generation a massacre of the young, an intensive competition to survive to maturity. Assuming that organisms vary, and that the variations are inherited—inheritable variations are known now in a great variety of different species—there will be a tendency for the better adapted animals or plants to outlive and outreproduce their brethren, and for the race to be steadily modified, generation by generation, in this way.

This hypothesis of Natural Selection is clearly quite distinct from the hypothesis of Evolution. Natural Selection is no more than a suggested explanation of the evolutionary process. There may be other and better explanations. Nevertheless, in the *Origin of Species*, these two ideas are not kept apart; they

are inextricably confused with each other. Darwin does not first establish the truth of evolution, and then produce Natural Selection as a possible mechanism: for him, the two ideas stand or fall together.

Now this is precisely what we are looking for—the reason why the *Origin of Species* created such a violent revolution in contemporary thought. It contained not only evidence that evolution had occurred but a plausible explanation of the occurrence. This, above all, was what the major treatises on evolution had hitherto failed to produce. The world was waiting for the explanation. Until it had the explanation, it would not trouble to accept the fact. Why should it? In the *Origin of Species*, Darwin achieved a tremendous feat of rationalization. He substituted rational evolution for miraculous creation. But if the evolution had not been rational, there would have been no great advantage in the change.

In Darwin's own mind one can see how the final recognition of the fact awaited the explanation. He suspected the truth of transformism while he was travelling round the world on the *Beagle*, and he opened his first notebook on the transmutation of species a few months after his return. But not until he had conceived and elaborated his hypothesis of Natural Selection did he dream of working up his material for publication. He wrote of—

> "the innumerable cases in which organisms of every kind are beautifully adapted to their habits of life—for instance, a woodpecker or a tree-frog to climb trees, or a seed for dispersal by hooks or plumes. I had always been much struck by such adaptations, and until these could be explained it seemed to me useless to prove by indirect evidence that species have been modified."

Thus, mounted on the back of Natural Selection, Evolution attacked and conquered the nineteenth-century world. It is interesting to trace the subsequent fate of the rider and the steed.

There followed upon the publication of the *Origin of Species* a tremendous outburst of critical scientific research into the truth of evolution. Animals and plants were dissected and com-

pared with each other in the light of the new teaching; classifications were overhauled and revised; the study of embryonic structure received a freshening inspiration; the fossil record was scrutinized with the most minute and painstaking care. The verdict of an army of investigators has been unanimous. The result of seventy-odd years of intensive inquiry has been to place Evolution on an unshakable foundation of fact. It has become the central generalization of biology. Looking back, one is amazed at the relative slenderness of the evidence that supported the earliest evolutionists, and at their temerity in basing upon it so revolutionary a doctrine.

But what of Natural Selection? What has happened to the hypothesis that made evolution acceptable to mankind? The answer is—practically nothing. While our knowledge of the steps through which organisms have evolved has been progressively consolidated, the hypothesis of Natural Selection rests pretty nearly where it did at the time of its formulation.

If one were to take a census of the biologists of to-day, one would find them—except in Tennessee, where the law forbids it—unanimously evolutionists. But one would probably find only a small proportion of active believers in Natural Selection—except in Russia, where it is part of the official creed. This does not mean that the majority of biologists believe the hypothesis of Natural Selection to be wrong; it means that they are neutral. They leave it alone. There is of course a big difference between believing that a proposition is false and abstaining from the belief that it is true.

Oddly enough, the very qualities that enabled Natural Selection to serve as sugar for the evolutionary pill make it unsatisfactory as an instrument of modern scientific thought.

We have already seen that Natural Selection affords an intelligible explanation of adaptive features, such as the feet of woodpeckers and tree frogs, or the hooks and plumes of seeds. But it is evident that the selective process will only operate in favour of characters that confer some advantage on their possessors. One of the most dangerous objections that have been raised against Darwinism is that many characters are apparently not advantageous. Most of the differences which enable the systematist to distinguish one species from another serve

no apparent purpose; and there are several well established fossil pedigrees in which useless structures have been evolved —such as the strange bifid horns that slowly grew on the noses of the Titanotheres, an extinct group of rhinoceros-like mammals, or the fantastic ornamentation with which many of the Ammonites decorated their shells.

The selectionist has a ready reply to this criticism. Often a single inheritable variation affects more than one character of the organism. The various anatomically distinct strains of wheat differ also in their susceptibility to the disease called rust; the white and coloured populations of America die from different illnesses; and there is evidence that immunity from measles is correlated with hair and eye colour. One may therefore account for the evolution of useless characters by supposing them to be accompanied by unknown advantages. Even a disadvantageous character might prevail if it were linked to a sufficiently profitable adaptation.

It will at once be seen that the hypothesis of Natural Selection is a very formidable explainer of data. Indeed, it is not easy to imagine any facts (short of downright, repeated discontinuity in the fossil record) that, properly manipulated, it would fail to explain. Let us illustrate this point, which is of great importance, by considering for a moment one of the best known chapters of the record of the rocks—the evolution of the horse. The story is now known in considerable detail, and is based on tens of thousands of specimens. It begins about forty million years ago, with an animal about as big as a medium-sized terrier, having five toes on each foot, comparatively short limbs, and simple teeth. Gradually this creature evolved into the modern horse. Its bulk increased; its legs became longer so that it could run more swiftly, and at the same time one of the toes on each foot grew into a stout lever, its nail becoming a hoof, while its neighbours dwindled and disappeared; the molar teeth became larger and more complicated, so that they could thoroughly grind up vegetable food. Manifestly, these facts lend themselves to a Darwinian explanation. The modern horse is much better fitted to its mode of life than its five-toed ancestor, and the whole history can easily be attributed to selection of favourable variations.

We may observe in passing that there is not a shred of positive evidence for this view. It has yet to be shown that at any period the less advanced horses died younger than their brethren; indeed, there is not a single case known to science where a gradual evolutionary change can be shown to coincide with selective mortality. The interpretation is nevertheless a possible one.

Now suppose the fossil record turned upside down. Suppose that we suddenly discovered that we had been mistaken, and that the race had really evolved in the opposite direction, from the horse to the little unspecialized ancestor. Would this afford a confutation of Natural Selection, or would the hypothesis adapt itself to the reversal?

There is no doubt at all that in the hands of a skilful exponent—and it has had many—Natural Selection could account for the new facts with the utmost ease. The foot of a one-toed horse, he would argue, is possibly very serviceable in running, but it is not plastic; it is limited in the things it will do, and by evolving five less specialized toes the race has acquired a more adaptable limb. The horse has raised itself to a new level of biological efficiency. Similarly, the reduction of the teeth was desirable, because they had previously occupied a disproportionately large part of the skull. (These supposed arguments are only mild caricatures of the ones with which an anatomist consoles himself for lacking the powerful arms and jaws of a gorilla. There are plenty of examples in the literature of reasoning as specious as this.) In the last resort, our selectionist could of course call linked characters to his aid, and suggest that the more toes a horse had, the more immune it was against diseases.

It was this very ability to explain any and every fact that gave Natural Selection its initial importance. The world was weary of unquestioning faith in Genesis and was hungry for explanations. But the scientist of to-day has different needs. His hypotheses must not only explain, they must discriminate. There must be possible facts that they would fail to explain. Just as a warrior is not really a warrior until he has fought and killed an enemy, so a theory, until it has run the risk of disproof, is not satisfyingly true.

As an illustrative contrast to the Darwinian hypothesis, we may take the brilliant generalizations known as Mendel's laws of heredity. By means of these laws one can make definite prophecies about the outcome of particular crosses. One can first anticipate, not only the different kinds of progeny that will emerge, but the relative numbers in which they will appear, and then test the inference experimentally and see whether its theoretical basis is correct. Thus, if one hybridizes pure-bred yellow and green peas, and inbreeds the hybrids, the second generation should consist of yellows and greens in the ratio of three to one. Seven different investigators have made the experiment; their results, added together, come to 152,824 yellows and 50,676 greens—a ratio of 3.01 to 1. The departure from expectation is trivial. If the ratios had been four to one or two to one, there would have been something wrong with the laws.

These laws of heredity were obscurely published by the Abbé Mendel in 1865, but the world was not ready for them, and they attracted little attention until they were rediscovered by a group of botanists in 1900. Their resuscitation gave a world-wide impetus to the study of genetics. They were tested again and again and found to be good; with their aid a magnificent structure of accurate knowledge about heredity has been built up in thirty years. This is one of the major triumphs of twentieth-century biology.

On the other hand, although the *Origin of Species* was published three quarters of a century ago, the hypothesis of Evolution by Natural Selection has yet to undergo a really critical test. Because of the very facility of the theory, such a test would be difficult to devise, and probably even harder to execute. But one may safely prophesy that until it is brought within the range of possible disproof, Natural Selection will play no further part in the development of biological knowledge.

Happily, there are indications that the hypothesis will not remain permanently inaccessible to critical investigation. J. B. S. Haldane and R. A. Fisher in England, and S. Wright in America, have performed the extraordinarily complicated feat of describing mathematically the action of Natural Selection

on populations of different types, so that the various possibilities can be stated and discussed with more precision than hitherto. H. J. Muller, of the University of Texas, has shown that the rate with which inheritable variations appear in a fly can be increased about 150 times by irradiation with X-rays. It may soon be possible, by choosing a rapidly breeding species, so that the experiments can cover a large number of generations, to make an animal adapt itself to a variety of different environments. Then we shall be able to assess more accurately what part selection plays in the process.

There we have a problem that may be tackled at some future time. For the present, Natural Selection is in ill favour because it explains too much and too readily. It is too unassailable. Hypotheses must live dangerously nowadays if they are to live at all. Until the position of Natural Selection is made more dangerous the theory will remain what it is and what it has been ever since its formulation—a perfectly credible explanation of the evolutionary process, but not necessarily the true one.