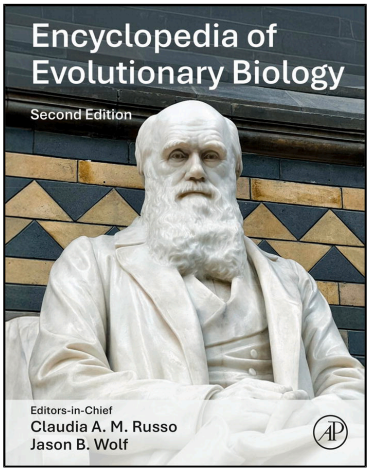

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Darwin–Wallace Theory of Evolution

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Key Points

- Biological evolution
- Charles Darwin
- Alfred Russel Wallace
- History of science
- Natural selection

Abstract

The Darwin–Wallace theory of evolution by natural selection has revolutionized the life sciences and much else. The story of Darwin and Wallace has been so frequently retold over the years that it has accrued many myths and legends. This article gives a historically accurate overview based on the latest contextual research and primary sources.

Introduction

The Darwin–Wallace theory of evolution is arguably the most important and widely influential in the entire history of science (van Helvert and van Wyhe, 2021). It has resulted in one of the most revolutionary changes in human thinking with profound consequences for research in a wide swathe of areas including biology, geology, palaeontology, taxonomy, ecology, philosophy, anthropology, psychology, literature, medicine, art and theology.

The Darwin–Wallace Theory of Evolution

The theory of evolution and its origins have been written about, discussed, and debated more than any other. The story of its origins has been retold countless thousands of times over the past 160 years. Like any tale endlessly recounted, the story has considerably evolved in the telling. There are now more myths and legends about this topic and its principal players, Darwin and Wallace, than perhaps any other in the history of science.

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In order to understand the origins of the theory, it is necessary to understand the people and events in their original historical contexts. One of the most persistent myths is that evolution was the answer to a timeless problem or mystery which scientists long sought to solve or discover. Nothing could be further from the truth.

The Age of the Earth

In Christian Europe, the world was traditionally held to be about 6000 years old based on interpretations of the Bible, which itself gave no dates or age for the Earth or creation. But by the early nineteenth century the accepted age of the Earth had changed through the work of many scholars studying mining, geology, and fossils. Although almost all of these scholars were devout Christians, from the continued investigation of the Earth itself, it came to be universally accepted by educated people that the world was extremely ancient. It was Christian geologists who established that the story of the worldwide flood of Noah in the Bible did not literally occur. With the discovery of ever more fossils, another dramatic fact about the history of the world was uncovered and became widely accepted. The history of life on earth had been generally progressive. The most primitive forms such as shells and ferns had preceded the more complex forms such as crustaceans and conifers. In later rocks reptiles appeared followed in the comparatively recent rocks by the first mammals, although of extinct types. Yet nowhere in the immense history of living things were any human fossils or artifacts found. Humans were clearly a far more recent species to appear. This led some to believe that the creation stories in the Bible only referred to the most recent of many creations, the one that concerned humans.

Catastrophism

At the beginning of the 19th century, the French comparative anatomist Georges Cuvier, through his detailed analyses of fossil bones such as the mammoth and the *Megatherium*, first proved an extremely controversial point. Extinction was a fact. Before this, many scholars held that the suggestion that species could go extinct was irreligious and impossible. Surely God would not allow something he chose to create to fail and vanish. Cuvier's excavations in the Paris basin showed that the further back in time one moved, the more different were the kinds of living things. Each era represented in the rocks was characterized by its own flora and fauna. These periods seemed to Cuvier to have been abruptly ended by sudden disasters and been followed by subsequent environments characterized by a new and unique flora and fauna. For someone who had lived through the French revolution, perhaps it is not surprising that Cuvier characterized these changes from era to era as revolutions. Cuvier's view is usually caricatured in recent accounts as an old-fashioned theory of "catastrophism." But it was extremely advanced at the time.

Lamarckism

In opposition to Cuvier's theory of extinction, the French naturalist Jean-Baptiste de Lamarck argued that unfamiliar fossil species had not gone extinct but had changed or evolved. For well more than a century now Lamarck's theory has almost always been misrepresented as evolution by the inheritance of acquired characteristics. This is a very inaccurate shorthand. The inheritance of acquired characteristics was not invented by Lamarck, it was not the core of his theory, and it was a very common belief among 18th- and 19th-century naturalists. Lamarck's theory for most of his working life was instead driven by a "complexifying force" which drove species to become ever more advanced. Along the way Lamarck argued that inheritance of acquired characteristics allowed organisms to adapt to their particular environments. Cuvier so powerfully discredited Lamarck and his theory of evolution that for many years any type of evolution was considered unscientific and absurd.

More Species

Another great change in scientific knowledge was the number of species known to exist. This went from a few hundred known to scholars such as John Ray (1627–1705) in Europe and the Mediterranean areas to countless thousands by the early 19th century. As European ships began to circle the globe, new species became known, from the porpoise and the dodo to the strange marsupial creatures of Australia. From Africa came the first specimens of chimpanzees and from Southeast Asia the first Orangutans. Systematists created elaborate systems to arrange and sort them. The great Swedish botanist Carl Linnaeus created the most simple and workable system with his binomial nomenclature and descending categories. It was found that whole classes of organisms were closely linked to one another through chains of similarities. Even more fundamentally, it was found that all groups fit as subgroups within larger ones, so that, for example, all species of wolves were classed with foxes, jackals, and dogs as canides. This pattern would later be explained by the Darwin–Wallace theory of branching evolution.

Uniformitarianism

Many histories incorrectly attribute the developments outlined so far, such as modern geology with its ancient earth and fossil record, to the Scottish geologist Charles Lyell and his influential work *Principles of Geology* (1830–33). But this is another modern shorthand where the work of a generation is attributed to one man who created a summary of the state of knowledge up to his time but with his own explanatory framework.

Lyell conducted extensive fieldwork. He examined the volcano Mount Etna in Sicily and showed that it must have grown slowly over a vast period of time through many eruptions. Lyell argued that events that appeared sudden on a geological scale could be the result of a long sequence of less abrupt changes. This aspect of his theory is the one usually remembered as "uniformitarianism," and is held up as the key to Lyell's theory. A supposed debate between "uniformitarians" and "catastrophists" is often invoked. Yet this was not the issue at the time, and indeed Lyell was probably the only "uniformitarian." Lyell's fellow geologists had no problem with mundane causes explaining past events but they objected to his insistence that causes of the same (or uniform) intensity as those of the present were all that had ever existed.

In addition to his survey of geology, Lyell also discussed what is now called palaeontology. He carefully surveyed the evidence for the successive appearance and disappearance of species in the geological record. Here too he tried to show that gradual natural processes were responsible. Because it was then believed that species could not change, they would eventually become extinct as their environments slowly changed beyond their limited ability to adapt. So, extinction became a gradual and piecemeal process rather than the result of global and era-ending disasters. The question was starting to arise, where did the subsequent species come from? Lyell accepted that species introductions were probably as piecemeal as extinctions and hypothesized that new species somehow appeared in accordance with the new environments. He seemed to allow that supernatural creation was involved with the appearance of new species. He was, however, fiercely opposed to Lamarck's theory of evolution and spent much of his book trying to discredit it.

Just as Lyell's *Principles of Geology* was coming out, a young English geologist working in South America was able to put some of Lyell's ideas about gradualism to the test. He was also to find Lyell's dodging of the question of where new species came from not entirely satisfactory. His name was Charles Darwin.

Darwin

Charles Robert Darwin (1809–82) was born in the small market town of Shrewsbury, England, to a wealthy upper middle-class family. His mother died when he was 8 years old. There is no evidence that he suffered any unusual effects from this as was once believed in line with the then fashionable Freudianism. Darwin was raised by his elder sisters and maidservants.

He attended the nearby Shrewsbury Free Grammar School as a boarder from 1818 to 1825. In October 1825 he was sent to Edinburgh University with his elder brother Erasmus to study medicine with a view to becoming a physician like his father Robert and famous grandfather Erasmus Darwin I. While in Edinburgh, Darwin studied marine invertebrates with the guidance of Robert Grant, a gentleman naturalist. Darwin did not like the study of medicine and could not bear the sight of blood or suffering and so his father proposed the church as a respectable alternative. The advantage to becoming a country parson would be the freedom to pursue a 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.

On October 15, 1827 Darwin was admitted a member of Christ's College, Cambridge (van Wyhe, 2014a). Darwin was never a model student, but he did mature into a passionate amateur naturalist. He began avidly collecting beetles. His name appeared in print when some of his records of insect captures were published in 1829.

Darwin became the devoted pupil of Professor of botany John Stevens Henslow (1796–1861). Through their close friendship Darwin learned a great deal about the practice of natural science. Darwin passed his BA examination in January 1831. Shortly thereafter he was taught advanced field geology by Cambridge Professor Adam Sedgwick during a geological tour of north Wales.

Voyage of the *Beagle*

Later in 1831 Henslow recommended Darwin for the post offered by Commander Robert FitzRoy for a naturalist to travel on a Royal Navy survey ship, HMS "Beagle." Contrary to recent fashion, Darwin was not on board as the captain's social companion, nor were ships' surgeons then always the "official naturalist" (van Wyhe, 2013b). Darwin had an official unpaid appointment to the post of naturalist by the Admiralty. Darwin was expected to investigate the natural history of the lands visited and this he did to a remarkable extent. He was also expected to deposit his collections in national collections.

The "Beagle" surveyed the coasts of the southern half of South America and the Galapagos islands and returned home via the Pacific, stopping at Tahiti, New Zealand and Australia. The voyage lasted 5 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. He recorded many of his specimens and observations immediately in field notebooks (Chancellor et al., 2009). Throughout the voyage Darwin shipped home specimens which soon earned him a reputation as a collector and observer of the first order. He recorded his experiences in a diary which became the basis of his famous book *Journal of Researches* (1839) now known as *Voyage of the Beagle* (Keynes, 2001; Darwin, 1839).

Darwin had the rare opportunity to witness all of the forces discussed by Lyell, such as erosion, earthquakes, and volcanic eruptions. Darwin made several very important discoveries about the geology of South America with vast parts of the continent showing signs of repeated uplift, volcanic islands, and the origins of coral reefs by building on Lyell's ideas.

Darwin also unearthed many previously unknown extinct fossil creatures in South America. He wondered why the fossils resembled the present inhabitants of that continent more than any other species. There was no evidence of catastrophic changes in the environment associated with the extinct species. Where had the new species that followed them come from? If species were

somehow created to fit their environments, as was then believed, why were tropical species different in Asia, Africa, and South America despite the similarity of climate?

The Galapagos

Only in the middle of the 20th century did Darwin's visit to the Galapagos come to be seen as a pivotal moment in his life, described as the occasion for a eureka-like discovery of evolution. Darwin did not become an evolutionist on the Galapagos and neither the islands finches nor their now famous beaks prompted a revelation either (Sulloway, 1982; van Wyhe, 2012). Darwin never speculated that the differently shaped beaks of the finches were adapted to different diets, that was the discovery of ornithologist David Lack in the 1930s–1940s. Only much later in England would the case of the Galapagos animals and plants influence Darwin's thinking to the point of convincing him that evolution must occur.

The Big Three

During the "Beagle" voyage and after his return, Darwin was particularly struck by three types of puzzling evidence: the succession of allied fossil forms in the same locale, the geographical distribution of species, and the similarity of the species of the Galapagos to those in South America (see Darwin, 1958, pp. 118–119). These three factors suggested to Darwin that species must evolve.

The species on the Galapagos, for example, were obviously very similar to those of South America, yet their rocky island home bore no connection or resemblance to South America. It seemed to Darwin that stray migrants from South America had come to the Galapagos, after the islands rose from the sea as volcanoes, and then changed over time in isolation on the islands.

Darwin also used the experience and observations of farmers and breeders to reveal that the purported limits or barriers to species changeability was a belief without foundation. Darwin mingled with pigeon fanciers to learn how they created extraordinary breeds by careful selective breeding (Secord, 1981) and he kept all the breeds he could acquire to experiment selectively breeding them himself.

In September 1838, Darwin read Thomas Malthus's *Essay on the Principle of Population* (1798). For many years it has been claimed that Darwin's theory of evolution was therefore influenced by the politics or economics of Malthus's book. In fact Darwin noticed was struck by the implications of explosive population growth potential in humans and other species. Malthus argued that animal and human population growth, unless somehow checked, would necessarily outstrip food production. The focus of this argument inspired Darwin. He realized that an enormous proportion of living things are always destroyed before they can reproduce. This must be true because every 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. Therefore only a few survived the struggle for existence.

Darwin embarked on a vast research program of reading and experimentation that would take many years to complete. In the meantime his primary occupation was the publication of his vast "Beagle" collections. This would take more than 10 years.

From the 1960s it became widely believed that Darwin kept his theorizing a secret and delayed its publication because he was afraid of the reaction. A large literature emerged to propose reasons or causes for this extraordinary secrecy and 20-year delay. In fact both are modern legends. Darwin told his family, friends, and colleagues about his theorizing and his plans to publish a large book on it. Like all of his other book projects, the species theory took even longer than he originally imagined (van Wyhe, 2007, 2013a). Nevertheless, the 20 years of work on the theory was far less than the delay in publishing many of Darwin's other works.

Vestiges of Creation

In 1844 an extraordinary anonymous book appeared which became a Victorian sensation: *Vestiges of the natural history of creation* (Secord, 2000). The book was written by the Edinburgh publisher Robert Chambers. *Vestiges* argued that nature operated according to natural laws, and that a fundamental outcome of the way the laws worked was progress. In space, dust clouds evolved to form solar systems, the Earth itself evolved to make the planet more suitable for higher life forms and life itself evolved or "developed." Organisms produced offspring like themselves. But sometimes, according to an even higher natural law, they would produce an offspring of a higher type. Over time, this led to life progressing ever upwards, reminiscent of Lamarck's theory. Invertebrates, fish, reptiles, mammals, and finally humans had all followed in succession, and *Vestiges* hinted that something higher would follow us. Although widely attacked by the scientific community, *Vestiges* convinced many that life evolved. One of these was a young man named Wallace.

Wallace

Alfred Russel Wallace (1823–1913) came from a humbler background than Darwin though he too was a middle-class Englishman. Wallace's father, a solicitor by training, once had property sufficient to generate a gentleman's income of £500 per annum. But the family's financial circumstances declined so that by the time Wallace was born, they were living in a large cottage near Usk, on the Welsh borders. Nevertheless, Wallace was not working class as he is sometimes described by modern commentators nor can he be described as on the opposite side of the social spectrum from Darwin.

When Wallace was 6 years old the family moved to Hertford, north of London, where he lived until he was 14. Here Wallace attended Hertford Free Grammar School which offered a classical education, almost identical to Darwin's at Shrewsbury. Wallace left school aged 14 in March 1837, shortly after Darwin returned from the "Beagle" voyage. In recent years it has been widely claimed, though erroneously, that Wallace was forced to leave school early for financial reasons. He completed his grammar school education and left at the normal age. Wallace did not attend university like almost everyone else at that time.

Over the next decade Wallace pursued a series of jobs from land surveying to architect to an assistant teacher in Leicester. In 1848 he set out with his friend and fellow entomologist Henry Walter Bates to work as a specimen collector in the Amazon basin. In recent years it has become increasingly common to claim that they set out to solve "the problem of the origin of species." This is an apocryphal, even if romantic, story (van Wyhe, 2014b). There was no such "problem" recognized until after Darwin published *On the origin of species* in 1859. All of the evidence from Wallace at the time and throughout the rest of his long life demonstrates that he went to South America as a specimen collector. Wallace returned to Britain in 1852 but tragically lost his personal collection when the ship he sailed on burned at sea. Undaunted, he set out for another collecting expedition, this time to Southeast Asia, then sometimes called the Malay Archipelago.

Malay Archipelago

Over the next 8 years, Wallace and a vast and ever changing team of assistants (van Wyhe, 2015, 2018) made dozens of expeditions to islands from Singapore to New Guinea and collected 125,000 specimens of insects, birds, mammals, and so forth. Wallace discovered hundreds of new species including the world's largest bee and rarest cat.

In 1855, while living in the province of Sarawak on the great island of Borneo, Wallace wrote his first theoretical paper on species: "On the law which has regulated the introduction of new species" (Wallace, 1855). Wallace argued that: "Every species has come into existence coincident both in time and space with a pre-existing closely allied species." Although a lucid summary and analysis of the paleontological and biogeographical evidence of the time, the paper did not state that species evolve. Instead Wallace referred many times to them being "created" and left descent to be "inferred" as he later noted. Most modern readers, however, mistakenly assume that the essay openly declared evolution (van Wyhe, 2016). Thus arises the spurious mystery as to how Darwin and "failed" to see what Wallace was privately thinking at the time.

Wallace continued reading about geology and palaeontology and jotting notes about how he believed species changed. As he collected more and more specimens and observed the change of animals from island to island, his ideas about life also evolved. He was convinced that species must be related genealogically—not just somehow created to suit their environments. But he was certainly not, as many modern commentators put it, searching for a "mechanism" for how evolution works. This is a later manner of thinking and it is anachronistic to attribute it to Wallace at this time.

In February 1858 Wallace was on the island of Ternate in the Moluccas, the fabled spice islands, west of New Guinea, and then part of the Dutch East Indies. According to his later recollections, Wallace was suffering from a recurring bout of fever when he suddenly conceived of an explanation for the origin of new species. When he recovered, he wrote an essay entitled "On the tendency of varieties to depart indefinitely from the original type."

In this extraordinary essay Wallace reminded his readers of the well-known principle of the "struggle for existence" which kept population numbers in check. Modern readers often misinterpret this initial discussion as if it were about natural selection, but this is a mistake. After establishing the point about how in the normal state of the natural world, balance is maintained by the strong living and the weak dying, Wallace then made an analogy: just as there was a struggle for existence among individuals of a species, the same was true for varieties or races (essentially modern subspecies). As an environment gradually changed over time a species living in it would become unsuited and die out. Among its daughter varieties, there might be one that happened to suit the new environment. This variety would then become the new species. It could never return back to the parental form as that was now inferior in the new environment. This process, if reiterated over a long time, would lead, as Wallace's title declared, "varieties to depart indefinitely from the original type."

It was a brilliant scientific essay and demonstrates Wallace's independent formulation of a form of what Darwin called "natural selection." Nevertheless, historians of science have long discussed and debated the many differences between Wallace and Darwin's views. The essay is heavily influenced by Wallace's study of his copy of Lyell's *Principles of geology*. Years later Wallace recalled that he had been inspired by Malthus. This is certainly possible but should not be repeated incautiously as if a straightforward fact. Wallace made no mention of Malthus in his essay or in his notebooks at the time and only did so after reading Darwin who stressed the work of Malthus. The principles that are reminiscent of Malthus in Wallace's essay were found in the writings of Lyell and others before him.

Darwin Versus Wallace?

What happened next has been surrounded by confusion and conspiracy theories for decades. Wallace did not send his essay, his first overtly evolutionary writing, for publication. This was the only publishable article Wallace did not send directly for publication. A few weeks after writing it he received an extremely encouraging letter from Darwin who praized Wallace's (1855) paper and mentioned that Charles Lyell also thought highly of it.

Wallace was inspired. If the Sarawak paper had impressed the great Lyell, perhaps the new Ternate essay would impress him too. Perhaps Wallace could even convince Lyell that his own principles actually supported, rather than contradicted, evolution. So

Wallace sent his essay to Darwin, whom he knew to be preparing a large work on evolution, with the request that it be forwarded on to Lyell if sufficiently interesting.

For decades it was believed that Darwin might have lied about when he received Wallace's letter and essay. Based on this uncertainty some even claimed, without any evidence, that Darwin might have plagiarized from Wallace. In fact, we now know that Darwin received Wallace's essay exactly when he said he did (see van Wyhe and Rookmaaker, 2012; van Wyhe, 2013a). Given our knowledge of these events as established by accredited scholars, leaving room for the possibility of lying about the date of the receipt of Wallace's letter or acquiring any ideas from it have no place in serious scholarship.

Darwin was by then about 2 years away from completing and publishing his big book on species. Surprised by Wallace's essay, but very much the Victorian gentleman, Darwin immediately forwarded it to Lyell as requested. Darwin even proposed sending Wallace's essay for publication and giving up his own 20 years of priority in publishing natural selection.

Concerned that their friend would lose the priority of first publishing his ideas, Lyell and J.D. Hooker arranged to have extracts from Darwin's manuscripts written in 1844 and 1857, together with Wallace's 1858 essay, read before the Linnean Society of London on July 1, 1858. These documents were published together as a joint contribution in the Society's proceedings in August 1858 (Darwin and Wallace, 1858). Thus began the long series of events that are usually called the Darwinian revolution.

It should be noted that scientific convention at the time recognized not only priority of publication, which Darwin and Wallace shared, but also priority to first conceive of an idea and also priority in first sharing an idea with other men of science. Darwin of course had priority in these latter two areas and his own intentions about having Wallace's essay published first could not have affected these other two forms of priority. Wallace himself noted that priority was usually granted to the first discoverer in his letter to J. D. Hooker upon hearing about the Linnean arrangement: "I cannot but consider myself a favored party in this matter, because it has hitherto been too much the practice in cases of this sort to impute *all* the merit to the first discoverer of a new fact or a new theory, & little or none to any other party who may, quite independently, have arrived at the same result a few years or a few hours later" (van Wyhe and Rookmaaker, 2012).

Starting in the 1960s there has been an increasing number of suggestions that something about the joint announcement was unfair to Wallace or that he has been otherwise unfairly treated or forgotten. The victim-hero Wallace myth has been the result. The arrangement was perfectly correct according to the standards of the time. Wallace's essay was not marked private or not to be published, so that publishing it was permissible. Wallace was both flattered and delighted when he found out about the arrangement. Indeed it was described in this way by all of the participants, their contemporaries and later commentators for over a century. Nevertheless the papers were very brief and easy to read as only a contribution to debates about varieties. No unambiguous evidence has ever been brought forward that any converts to evolution were made by the joint presentation or papers.

Responding to appeals from others, Darwin began to prepare a summary or abstract of his larger work for publication. This project too lengthened far beyond his original plan and eventually became the 500-page *On the origin of species* (1859). The book condensed Darwin's massive research program of 20 years into a single volume. All of the most likely objections were openly acknowledged and answered.

The book immediately became extremely controversial and very widely discussed. Despite the fact that it argued against some of the most fundamental scientific views of the time, and for many was also considered religiously or morally unacceptable, the book almost single-handedly convinced the international scientific community to accept that evolution is a fact within 10–15 years. Darwin's foremost public proponent was the naturalist T.H. Huxley. Almost every mention of him in the modern literature states that he was so energetic in the defense of Darwin that he was widely known as Darwin's bulldog. It has recently been shown that this is totally false, he was never known by this nickname during his lifetime (van Wyhe, 2019).

As Darwin's book had this dramatic effect, the theory and its success were, from the beginning, attributed to Darwin by contemporaries, including Wallace. This is the only reason for the differential fame, credit and indeed influence of Darwin and Wallace. *On the origin of species* included many components not present in Wallace's essay. These included the analogy of man's selective shaping of domesticated plants and animals and the relevance of that process to what occurs in nature, laws of variation, transitional varieties, inherited instincts, family selection, hybridism, divergence of forms due to available ecological spaces, recapitulative embryology, taxonomic classification, no inherent progress, sexual selection, vestigial organs as remnants, geographical distribution, and natural dispersals rather than former land bridges. Wallace was among Darwin's foremost supporters and admirers. The theory was therefore commonly called "Darwinism." Wallace (1889) also promoted this language, by then already fully established, including his own great book on the theory, second only to the *On the Origin of species*, called *Darwinism*.

Conclusion

After the work of Darwin and supported and reinforced by the work of Wallace, H. W. Bates, Huxley, Hooker, E. R. Lankester, John Lubbock and very many others, the question of whether or not evolution occurred was never again scientifically in doubt, though natural selection and indeed inheritance, along with a number of other aspects of the theory remained problematic until the first few decades of the 20th century when the so-called modern synthesis of evolution by natural selection with "Mendelian" genetics diminished such concerns. Indeed, it remained for generations of workers to work out the many details and profoundly important and complex implications. Hence there is a tension in referring to a singularity called "the Darwin–Wallace theory of evolution" because this reduces a large body of theoretical ideas, perspectives and data stemming from *On the Origin of species*, which most people mean when they refer to evolutionary theory, to only branching descent with modification via natural selection.

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