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The Reception of Charles Darwin in Europe
Volume I

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continuum

Contents

1 Darwin's Philosophical Revolution: Evolutionary Naturalism and First Reactions to his Theory[1]

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With his theory of descent Charles Darwin created the paradigmatic framework of today's biology for understanding the evolution of organisms. Darwin offered an explanation of the origin of new species and of the functional character of the traits of organisms, their adaptations, by invoking a unitary scientific principle or mechanism. The revolutionary character of his solution is that he achieved this without drawing on religious or other metaphysical assumptions, like goal-directed forces immanent in nature or a Creator God, an intelligent designer.

Inasmuch as the reception of Darwin covers an impressive range of countries, contexts and disciplines, and since he was interpreted in diametrically opposed ways, it is advisable to have a look at Darwin at the very beginning. The aim of this chapter is to introduce a study of his reception in Europe with a brief sketch of Darwin's biographical and intellectual background, a reminder of his main scientific, theological and philosophical roots, outlining both his methodology and his theory in order finally to present some of the first reactions to it in the early phase of reception in Britain. This will provide a groundwork for the innovative studies of his reception across the countries and disciplines of Europe.

Initially Darwin had intended to substitute the widespread biblical idea of the divine special creation of each species by the assumption of laws established by God. Here Darwin was oriented to other natural sciences, particularly physics and astronomy, which presupposed such laws and had already successfully worked with them for centuries. However, the law formulated by Darwin rendered the idea of God as the creator of this law dispensable for biology. Darwin could explain the formation of species as well as that of adaptations by one and

[1] I thank Thomas F. Glick for his thoughtful reading of the English text. This chapter grew out of my keynote lecture 'Science and Religion in the Life and Work of Charles Darwin', 9 September 2001, at the Conference of the European Science Foundation 'Explanatory Models and Public Understanding: The Debate between Science and Religion' (Chair: Dr Elinor Shaffer) in Exeter, United Kingdom, 8–12 September 2001. It is also based on my monograph, *Charles Darwin* (2007).

the same principle, without having to presuppose an intelligent first cause as creator of these laws. He could show how purposive, functional structures could arise without having to presuppose an intelligent entity who set the purpose and constructed organisms according to his design.

Darwin was deeply influenced and inspired by philosophy of science, particularly by the astronomer and philosopher Sir John Herschel (1792–1871) and by the philosopher, mathematician, historian, and later master of Trinity College, William Whewell (1794–1866), who were both convinced adherents of natural theology and who pictured themselves within the tradition of Francis Bacon (1561–1626), the father of modern philosophy of science, as well as of Isaac Newton (1647–1727).[2] We can only understand the core of Darwin's revolution and the harshness of some of the first reactions to his theory (as well as its rejection by clerical circles) when we go back to some of the writings of Herschel and Whewell by which the young Darwin was influenced. By applying their philosophy of science and pursuing their ideas, Darwin finally surpassed them and broke out of the natural theological framework from which he had started.

Darwin's family background: Enlightenment, humanity, nonconformism

Charles Darwin was born in Shrewsbury, Shropshire, on 12 February 1809, the fifth of six children of the successful and well-liked physician Robert Waring Darwin (1766–1848) and his wife Susannah Darwin (1765–1817), born Wedgwood. Darwin's parents came from renowned and well-off English families. Both grandfathers, the physician, naturalist, inventor and poet Erasmus Darwin (1731–1802) and the potter and inventor Josiah Wedgwood (1730–95) were leading members of the landed gentry, both Fellows of the Royal Society (Browne 1995; King-Hele 2000). They were attached to each other by a deep friendship and congeniality, rooted in common humanitarian ideals, a critical attitude towards the Crown and the Church of England, adherence to the liberal Whig party and by common economic interests in the flourishing early industry of England. On the burning questions of the day both supported the American independence from England and the anti-slavery campaign, as well as the French Revolution. Josiah Wedgwood was a Unitarian, a religious denomination which rejects the trinity and believes in God as a unity. According to Charles Darwin, his grandfather Erasmus Darwin did not 'feel much respect for unitarianism, for he used to say that "unitarianism was a feather-bed to catch a falling Christian" ' (2003, 63). He describes him as a theist who 'disbelieved in any revelation'. Most likely Erasmus Darwin was a deist. He was influenced by the Scottish Enlightenment during his time in Edinburgh, where he also became a friend of Albert Reimarus, the son of the German philosopher Hermann Samuel Reimarus, who was influenced by English deism, sceptical of Christianity and a proponent of natural rather than revealed religion (Gawlick 1973; King-Hele 2000, 17). In 1769 Erasmus Darwin writes in a letter to his former friend Albert Reimarus:

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[2] For more philosophical influences see Engels 2007.

'Mr Keir and myself continue in the Religion you taught us, we hold you to be a great Reformer of the Church' (King-Hele 2000, 17). To sum up, both of Charles Darwin's grandfathers were nonconformists and dissenters.

Erasmus Darwin was well known as a naturalist for his poems on organic life which interested the Romantic poets Wordsworth, Coleridge, Shelley and Keats. Moreover, he went down in the history of biology for his work *Zoonomia; or The Laws of Organic Life* (1st part 1794, 2nd part 1796). This work was translated into German, Italian, Portuguese and French and there were at least five American and three Irish editions. As early as February 1795 an article was published in the *European Magazine and London Review* on 'Dr. Erasmus Darwin', in which the importance of Darwin's *Zoonomia* for medicine was compared to the importance of Isaac Newton's *Principia* for natural philosophy. Erasmus Darwin was also highly esteemed in Germany. In 1889, Otto Zöckler, professor of theology at the University of Greifswald, Germany, published a 32-page article on Darwin's grandfather, physician, poet and natural philosopher, in which he described Charles Darwin as standing directly on the shoulders of his ancestor without having needed a Jean Lamarck as an intermediate link between his grandfather and himself.[3] Alexander von Humboldt expresses his high estimation of Erasmus Darwin in his letter to Charles Darwin (Burkhardt and others 1986 [1837–43], 2: 218). The German neo-kantian philosopher Jakob Friedrich Fries mentions several times in his work Erasmus Darwin's observations and reflections on colour vision in his *Zoonomia* (for instance Fries 1973, 308). Darwin's *Zoonomia* also influenced Charles Darwin's theory formation as we can see from Notebook B which even bears the heading *Zoonomia*.

In his *Zoonomia* (vol. I) of 1794, which was published in the same year as William Paley's *Evidences of Christianity*, Erasmus Darwin supported a view of nature and life which was defended by Philo, one of the three dialogue partners in Hume's *Dialogues Concerning Natural Religion*, posthumously published in 1779. Darwin is fascinated by the thought

> that the world itself might have been generated, rather than created; that is, it might have been *gradually* produced from very small beginnings, increasing by the activity of its *inherent principles*, rather than by a sudden evolution of the whole by the Almighty fiat. (1794, 509, last emphasis is mine)

Erasmus Darwin however does not dispense with the assumption of 'The Great Architect', 'The Cause of Causes', 'Parent of Parents', 'Ens Entium'. But this architect plays another role than in the biblical tradition. According to Erasmus Darwin, 'it would seem to require a greater infinity of power to cause the causes of effects, than to cause the effects themselves'. It seems that for Erasmus Darwin the assumption of a creator of the world was compatible with the idea that the creator as ultimate or first cause of the universe had outfitted his creation with laws according to which it now gradually evolved (on Hume's Dialogues see section 'The Background of Natural Theology' below). Years before Charles Darwin's birth, Samuel Taylor Coleridge, who was interested in,

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[3] 'Jedenfalls bedurfte der Darwin der Gegenwart, um zu werden, was er geworden ist, nicht erst eines Lamarck als Zwischengliedes zwischen seinem Großvater und sich.' (Zöckler 1880, 153)

though sceptical of, Erasmus Darwin's poetry, especially of his *Temple of Nature*, coined the term 'Darwinizing' to express his scepticism about Darwn's idea of a gradual evolution of new species, (Barlow in Darwin 1969, 150; Coleridge 1875, 423).[4] Erasmus Darwin already had to face those criticisms his grandson later dreaded.

Howard Gruber has named the sum of this critical potential in Charles Darwin's family a 'Family Weltanschauung' (Gruber and Barrett 1974, 46). Thus Darwin's grandfathers had already paved in different manners the way for their grandchild.

The student of medicine and theology

Darwin was supposed to continue the family tradition and study medicine in order to become a physician like his grandfather and father before him. Therefore his father sent him to the University of Edinburgh, where his brother Erasmus was completing his medical studies. Charles, however, was neither interested in most lectures and courses nor could he stand the sight of medical operations. He attended on two occasions the operating theatre in the hospital at Edinburgh and witnessed two very painful operations (one on a child), but rushed away before they were completed:

> Nor did I ever attend again, for hardly any inducement would have been strong enough to make me do so; this being long before the blessed days of chloroform. The two cases fairly haunted me for many a long year. (Darwin 1969, 48)

After Charles Darwin had spent two sessions in Edinburgh his father realized or heard from his daughters that Charles did not like the thought of becoming a physician, so he proposed that he become a clergyman. Darwin asked for some time to consider, having scruples about declaring his belief in all the dogmas of the Church of England, though otherwise he liked the thought of being a country clergyman. 'And as I did not then in the least doubt the strict and literal truth of every word in the Bible, I soon persuaded myself that our Creed must be fully accepted' (1969, 57).

Darwin studied theology at Christ's College, Cambridge, and received the formal pass degree of BA. During his years at Cambridge he dedicated himself with much enthusiasm to his interest in natural science. For this, Cambridge was an ideal intellectual environment, because here Darwin met the most famous thinkers of the century, visited their classrooms and houses, took walks with them and accompanied them on excursions. Darwin had several famous mentors and friends. The most important were John Stevens Henslow (1796–1861),[5] professor of botany and mineralogy and an excellent expert in a variety of fields of natural sciences, and Adam Sedgwick (1785–1873), professor of geology, with whom he studied geology for two semesters after finishing his BA in theology. According to Darwin his friendship with Henslow influenced his whole career more than any other (1969, 64). David Kohn and others have shown in their

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[4] See also the definition of 'Darwinising' with reference to Coleridge in *A New English Dictionary on Historical Principles* 1897, 39.

[5] Henslow later left Cambridge and became a country parson (Bowlby 1992, 362).

remarkable article that Henslow influenced Darwin in an even more specific way than was formerly assumed. The creationist Henslow established a huge herbarium of British flora to serve as the tool for an inquiry into species and their limits. 'The distinctive feature of Henslow's herbarium was his practice of comparing specimens, which he called "collation" ' (Kohn and others 2005, 643). He organized them in such a way that the variation of individuals within a species became obvious. Thus Henslow wanted to show that species have the capacity to vary, but only within stable limits. The authors come to the conclusion that by his herbarium nevertheless 'Henslow provided the context not only for Darwin's botanical studies but also for his comprehension and very acceptance of evolution' (2005, 643). The 'henslovian framework he had been given at Cambridge switched into a new configuration' (2005, 645). Darwin could draw on the method and research programme of his former teacher, but they supplied him with the possibility of a theoretical Gestalt switch: not the stability but the permeability of species limits was to be attested.[6]

The background of natural theology

A number of historians and philosophers like Reijer Hooykaas, Charles C. Gillispie, John H. Brooke, John Durant, Janet Browne and others have shown that for centuries there had been a tight alliance between science and religion, construing science as a worship of God by proving his traits in the minute study of his creation. As Janet Browne put it: 'Science, in a sense, *was* religion' (1995, 129). From the seventeenth century on there were outstanding scientists as well as philosophers of science who defended some kind of natural theology, among them Francis Bacon, Isaac Newton, Joseph Priestley, Sir John Herschel and William Whewell.

Darwin grew up in an educational system where this kind of reasoning and the language of natural theology belonged to everyday life. According to John Durant it is important to recognize that

> Darwin was trained in the tradition of English natural theology, that the problems with which he dealt were those of English natural theology [. . .] Darwin received virtually the whole of his formal instruction in natural history whilst preparing for the Anglican ministry at Christ's College, Cambridge; theory was provided by Paley, whose work made a lasting impression, and practical classes were conducted by the Reverend John Stevens Henslow (botany) and the Reverend Adam Sedgwick (geology). It would require quite extraordinary powers of inattention to survive such an education without acquiring a thorough acquaintance with the principles of natural theology, and we know that Darwin was very far from being an inattentive student. (Durant 1985, 16)

William Paley indeed was one of the main representatives of *natural theology* and its *argument from design*. Paley's works were part of Darwin's required reading in order to pass his BA examination in theology. He studied Paley's *Evidences of Christianity*, his *Moral Philosophy* as well as his *Natural Theology* very thoroughly

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[6] See the detailed biographies by Bowlby 1992 and Desmond and Moore 1991.

and with delight. He learnt the *Evidences* almost by heart and 'could have written out the whole' of this book 'with perfect correctness, but not of course in the clear language of Paley. The logic of this book and as I may add of his *Natural Theology* gave me as much delight as did Euclid.' At that time Darwin did not trouble himself about Paley's premises, as he admits, 'and taking these on trust I was charmed and convinced by the long line of argumentation' (1969, 59).

Paley's *Natural Theology; or Evidences of the Existence and Attributes of the Deity collected from the Appearances of Nature* was the standard work of natural theology which comprised the religious assumptions of natural philosophy and explained them in a particularly cogent way. Paley's model of design was the watch which needed for its existence a watchmaker.

> There cannot be design without a designer; contrivance, without a contriver; order, without choice; arrangement, without any thing capable of arranging; subserviency and relation to a purpose, without that which could intend a purpose; means suitable to an end, and executing their office in accomplishing that end, without the end ever having been contemplated, or the means accommodated to it. (Paley 1835, 3)

For Paley 'the marks of *design* are too strong to be gotten over. Design must have had a designer. That designer must have been a person. That person is GOD' (1835, 111). He rejects the idea that God had created the world, implanted laws and then retired.

> Effects are produced by power, not by laws. A law cannot execute itself. A law refers us to an agent. Now an agency so general, as that we cannot discover its absence, or assign the place in which some effect of its continued energy is not found, may, in popular language at least, and, perhaps, without much deviation from philosophical strictness, be called universal: and, with not quite the same, but with no inconsiderable propriety, the person, or Being, in whom that power resides, or from whom it is derived, may be taken to be *omnipresent*. He who upholds all things by his power, may be said to be every where present. (1835, 112)

Natural theology or physico-theology with its *argument from design* had already a longer tradition in English thought. Hume's *Dialogues Concerning Natural Religion* (1779) are a critical discussion of natural religion and its *argument from design*, as well as of revealed religion. Cleanthes, the proponent of the argument from design, claims that

> The curious adapting of means to ends, throughout all nature, resembles exactly, though it much exceeds, the productions of human contrivance; of human design, thought, wisdom, and intelligence. Since therefore the effects resemble each other, we are led to infer, by all the rules of analogy, that the causes also resemble; and that the Author of nature is somewhat similar to the mind of man; though possessed of much larger faculties, proportioned to the grandeur of the work, which he has executed. By this argument *a posteriori*, and by this argument alone, do we prove at once the existence of a Deity, and his similarity to human mind and intelligence. (Hume 1993, 45)

Philo, the sceptic, questions this argument, claiming that the 'world plainly resembles more an animal or vegetable, than it does a watch or a knitting-loom.

Its cause, therefore, it is more probable, resembles the cause of the former. The cause of the former is generation or vegetation' (Hume 1993, 78). Only a proof *a priori*, which is defended by Demea, could show 'both that order is, from its nature, inseparably attached to thought, and that it can never, of itself, or from original unknown principles, belong to matter' (Hume 1993, 81). But, according to Philo, there is no such proof *a priori*.

> For aught we can know *a priori*, matter may contain the source or spring of order originally, within itself, as well as mind does; and there is no more difficulty in conceiving, that the several elements, from an internal unknown cause, may fall into the most exquisite arrangement, than to conceive that their ideas, in the great, universal mind, from a like internal, unknown cause, fall into that arrangement. (Hume 1993, 48)

To Philo it therefore does not seem less plausible to explain the order and organization of nature by vegetation and generation than by reason and design; and generation even 'has some privileges above reason: For we see every day the latter arise from the former, never the former from the latter' (Hume 1993, 81). According to J. C. A. Gaskin, the editor of Hume's *Dialogues*, Paley's *Evidences of Christianity* (1794) and his *Natural Theology* (1802) 'had in effect been refuted by Hume in the *Dialogues* (1779) and elsewhere before they were even written; but Paley, not Hume, was the standard reading on religion for students throughout the nineteenth century and into the twentieth' (Gaskin in Hume 1993, IX).

It is assumed that Paley's book inspired Francis Henry Egerton, the eighth and last Earl of Bridgewater, himself a clergyman, in his will in 1829 to leave £8,000 to the President of the Royal Society with the aim of supporting this physico-theological world view, to be paid to one or several authors of one or several treatises which might corroborate the truth of natural religion out of scientific discoveries (Gundry 1946, 144). Eight scholars of distinction were nominated for these treatises. The *Notice* prefaced to *The Bridgewater Treatises* states that the writer or writers should produce a work or works

> On the Power, Wisdom and Goodness of God, as manifested in the Creation; illustrating such work by all reasonable argument, as for instance the variety and formation of God's creatures in the animal, vegetable and mineral kingdoms; the effect of digestion, and thereby of conversion; the construction of the hand of man, and an infinite variety of other arguments; as also by discoveries ancient and modern, in arts, sciences, and the whole extent of literature. (Gundry 1946, 144)

Among these eight authors were also William Whewell, William Buckland, who was the English representative of Cuvier's geological catastrophism, the anatomist and surgeon Sir Charles Bell and William Kirby, the first president of the Entomological Society and one of the founders of the Zoological Society. As we can see from Darwin's later writings he highly appreciated the thorough empirical investigations of some of these authors and drew on their rich and detailed findings. Although Darwin rejected Charles Bell's natural theological interpretation of the human face muscles, his *Expression of the Emotions in Man and Animals* contains many positive references to the descriptions in Bell's *Anatomy and Philosophy of Expression* (1806), and in *Descent of Man* he draws on Bell's Bridgewater Treatise, *The Hand* (1833), for support of his own position.

From Whewell's Bridgewater Treatise *Astronomy and General Physics, Considered with Reference to Natural Theology* (1833), Darwin takes a quotation as one of the epigraphs for the flyleaf of his *Origin of Species*.

There were numerous subsequent editions of *The Bridgewater Treatises*, some authors, like Whewell and Buckland, publishing up to nine editions. Most of these authors described God as an intervening and superintending deity whose role was not restricted to being the creator of nature and its laws, but who had *created* as well as still *governed* the world.[7]

The 'mystery of mysteries' – the 'origination of fresh species'

Darwin's intention to become a clergyman was never formally given up, 'but died a natural death' during his voyage on the *Beagle* as naturalist (Darwin 1969, 57).

> When on board H.M.S. 'Beagle', as naturalist, I was much struck with certain facts in the distribution of the inhabitants of South America, and in the geological relations of the present to the past inhabitants of that continent. These facts seemed to me to throw some light on the origin of species – that *mystery of mysteries*, as it has been called by one of our greatest philosophers. On my return home, it occurred to me, in 1837, that something might perhaps be made out on this question by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it. (Darwin 1964, 1; my emphasis)

Before Darwin drew up his 35-page-long *Sketch* in 1842 and wrote his 230-page *Essay* in 1844 he wrote several notebooks on geological and zoological subjects, on the transmutation of species (these are notebooks B to E) as well as on metaphysical questions (notebooks M and N and others) and several smaller notebooks.[8] These *Notebooks* reveal that Darwin was to the highest degree intellectually sensitive. He displayed competencies which are just now in demand, namely a genuine interdisciplinary curiosity and mode of research and working. Although he established his reputation as a natural scientist, certain assumptions and results of those disciplines which are nowadays called the 'humanities', like philosophy, theology, social sciences, etc. fulfil a constitutive, systematic function for the formation of his theory. Darwin lets the traditional philosophical and theological discussions of his time address and inspire him, while engaging them in a lively exchange. He tries to answer the questions left by the tradition within his evolutionary naturalism, to interpret them in a new way or to reject them as obsolete.

The unnamed great philosopher to whom Darwin alludes was none other than the astronomer and philosopher of science Sir John Herschel, whom Darwin admired and took as a role model.

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[7] For a discussion see Gillispie 1996; for an overview of the editions see Gillispie 1996, 298.

[8] Darwin's notebooks were posthumously published, first separately by Gavin de Beer (transmutation notebooks) and Howard Gruber and Paul Barrett (notebooks on metaphysical enquiries) and later together in one volume by Barrett and others in 1987.

> During my last year at Cambridge I read with care and profound interest Humboldt's *Personal Narrative*. This work and Sir J. Herschel's *Introduction to the Study of Natural Philosophy* stirred up in me a burning zeal to add even the most humble contribution to the noble structure of Natural Science. No one or a dozen other books influenced me nearly so much as these two. (Darwin 1969, 67–68)[9]

This statement in Darwin's autobiography of 1876 does not represent a later impression, for his enthusiasm for Herschel's book is already reflected in a letter of 15 February 1831, in which Darwin recommends that his cousin William Fox 'read it directly' (Burkhardt and others 1985 [1821–36], 1: 118). Herschel's *Discourse* 'became an authoritative statement of the methods of scientific investigation, anticipating John Stuart Mill' (Burkhardt and others 1985, 118 n2). Darwin's overall aim was to discover the *vera causa* of the formation of species as physics and other natural sciences had discovered the *vera causa* of phenomena of the inorganic world. He wanted to discover nothing more minor than the 'laws of life'.

However, it was not only this book but also a letter from Herschel to Lyell of 20 February 1836 which was highly influential for Darwin's project. This letter was published in the so-called *Ninth Bridgewater Treatise* of Charles Babbage. In this letter Herschel, who is at the Cape of Good Hope, thanks Lyell for the present of the new edition of the *Principles of Geology*. Herschel admits that he read this work 'for the third time, and every time with increased interest'. Herschel was aware of the revolutionary character of Lyell's geological view, his uniformitarianism by which he questioned the dominant catastrophism at that time propagated by Cuvier and his English adherent Buckland and many others. Lyell's work appeared to Herschel 'one of those productions which work a complete revolution in their subject, by altering entirely the point of view in which it must thenceforward be contemplated.' (Herschel 1836 in Babbage 1989, 94) This letter also contains the phrase 'mystery of mysteries', by which Herschel means 'the replacement of extinct species by others'. This is the crucial thought by which the young Darwin was fascinated, namely that species are not created separately by the Creator but that they come into being by natural laws. Darwin was encouraged and stimulated by Herschel in pursuing his search for secondary causes.

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[9] In various letters which Darwin wrote to his family and friends he enthuses over Humboldt's narratives, particularly his description of the Tropics. I 'read Humboldt: my enthusiasm is so great that I cannot hardly sit still on my chair' (letter to his sister Caroline, 28 April 1831 in Burkhardt and others 1985 [1821–36], 1: 122). Also in his letters during the *Beagle* voyage he praises Humboldt's 'sublime descriptions' (letter to Henslow of 18 May 1832 in Burkhardt and others 1985, 1: 236) and he recommends his father: 'If you really want to have a <notion> of tropical countries, *study* Humboldt' (ibid. 1: 204). Darwin sent Humboldt his *Journal of Researches*, which came out in 1839. Humboldt thanked Darwin in a long letter of 18 September 1839, in which he expresses his high estimation of Darwin's achievement. He praises his work for its 'nombre d'observations nouvelles et ingenieuses' (the number of new and ingenious observations) in a large variety of different areas and he predicts him a 'belle carriere a (*sic*) parcourrir' (a fine career to pass through) (18 September 1839, Burkhardt and others 1986 [1837–43], 2: 218). Later on, Darwin met Humboldt personally.

> For my own part, I cannot but think it an inadequate conception of the Creator, to assume it as granted that his combinations are exhausted upon anyone of the theatres of their former exercise, though in this, as in all his other works, we are led, by all analogy, to suppose that he operates through a series of intermediate causes, and that in consequence the origination / of fresh species, could it ever come under our cognizance, would be found to be a natural in contradistinction to a miraculous process – although we perceive no indications of any process actually in progress which is likely to issue in such a result. (Darwin 1989, 95)

In this letter Herschel also questions the biblical accounting of the time that had elapsed since the appearance of the human being on the earth. He bases his doubts on reflections on the period of time that had necessarily to be presupposed in order for all languages to have had a common origin: '– Time! Time! Time! – we must not impugn the Scripture Chronology, but we *must* interpret it in accordance with *whatever* shall appear on fair enquiry to be the *truth* for there cannot be two truths' (Herschel in Cannon 1961, 308). This letter shows that Herschel was by no means resistant to the idea that God governed the living world by laws, but he didn't 'perceive' any 'indications' for this assumption.

Darwin knew this letter and was not only familiar with the abridged version published in Babbage, which contains Herschel's reflections on intermediate causes, but also with his ideas about the age of the human being and his claim to interpret the Scripture in accordance with the actual scientific knowledge of a time. He had some correspondence with his sister Caroline on the time issue (27 February 1837, Burkhardt and others 1986 [1837–43], 2: 8). Darwin also knew Herschel personally, having visited him at the Cape of Good Hope in June 1836 while on the *Beagle* voyage.

Darwin pursues the idea of intermediate causes for his attempt to explain the appearance of new species. The notion of 'intermediate causes' has to be understood against the background of the old theological and philosophical distinction between the first cause (*causa prima*) and secondary causes (*causae secundae*). By *first cause* one meant God the creator, while *secondary causes* or secondary laws are those causes or laws to which nature and its events are subjected in accordance with God's purposes. These are those causes which Herschel names 'intermediate causes'; that is, they are between God's will and his products. Astronomers and physicists, when explaining natural events and processes, had for a long time been referring to natural laws, instead of ascribing these to the direct effect of God's will. For Francis Bacon the 'inquiry of final causes is a barren thing, or as a virgin consecrated to God' (1901 [1605], 109). Physics has to inquire into efficient and material causes.

> For the handling of final causes, mixed with the rest in physical inquiries, hath intercepted the severe and diligent inquiry of all real and physical causes, and given men the occasion to stay upon these satisfactory and specious causes, to the great arrest and prejudice of further discovery. (Bacon 2001, 93)

Bacon here has Aristotle, Galen and others in mind. However, he did not totally reject the pursuit of final causes but made a distinction between the scope of final or primary causes and that of secondary or efficient causes. The inquiry into final causes is not 'omitted', but rather is 'misplaced' in physics (Bacon 2001, 93). There one has to search for secondary causes. Final explanations and the inquiry

into final causes like those of Aristotle and Galen are 'well inquired and collected in metaphysic, but in physic they are impertinent' (Bacon 2001, 93–94). Bacon rejects not only the Aristotelian type of final causes in physics, but also the substitution of physical causes by God's assumed purpose. The pursuit of secondary causes, however, does not lead to atheism but to religion. 'For certain it is that God worketh nothing in nature but by second causes' (Bacon 2001, 9). In this context Bacon makes the famous statement that Darwin uses as one of the epigraphs of his *Origin of Species*.

> To conclude therefore, let no man upon a weak conceit of sobriety or an ill-applied moderation think or maintain, that a man can search too far, or be too well studied in the book of God's word, or in the book of God's works, divinity or philosophy; but rather let men endeavour an endless progress or proficience in both. (Bacon 2001, 9)

Darwin was interested in natural science in the sense of the Baconian tradition. The dominant doctrine of special creation was not satisfying for him from a *methodological* point of view. The other natural sciences had disposed with the idea of God permanently meddling in natural events. Why should this not hold for the sciences of living nature?

There were mainly three reasons why Darwin gave up the idea of a special creation of each single species by God. These are his observations and experience during his *Beagle* voyage including his Galapagos experiences, his sophisticated philosophy of science and knowledge of the history of science, and the image of God which is presupposed by the idea of a special creation.

Darwin's Galapagos experience

Darwin had been 'deeply impressed' by several discoveries on the South American continent and the Galapagos archipelago during the voyage of the *Beagle*: firstly, by the similarity between the armour of great fossil animals and that of the existing smaller armadillos; secondly, by 'the manner in which closely allied animals replace one another in proceeding southwards over the Continent'; and thirdly, by his experience of the Galapagos archipelago which was actually twofold, concerning the relationship between the species on the Galapagos Islands and those on the South American continent as well as the range of variation of these species on the islands themselves. Most of the species on these islands had a specific South American character, which means that they differed from the species of other places, even from those which were similar with respect to their physical and geological conditions, like the Cape Verdean Islands which were also volcanic islands. Moreover, the species on the Galapagos archipelago manifested differences among themselves depending on the island where they lived. For Darwin, it was 'evident that such facts as these, as well as many others, could be explained on the supposition that species gradually become modified; and the subject haunted me' (Darwin 1969, 118–19).

There are several hypotheses about when exactly Darwin became convinced that species are mutable, whether at the beginning of, during or after the *Beagle* voyage. Most Darwin scholars think that this 'conversion' happened after his return to England. For the purpose of this article it is not necessary to pursue this question in detail (see Engels 2007, chap. II, 2). According to Darwin's own

memory it was in the year 1837 or 1838 that he became 'convinced that species were mutable productions' (Darwin 1969, 130). In his private journal he writes under 1837 that in 'July opened first note book on "Transmutation of Species" – Had been greatly struck from about Month of previous March on character of S. American fossils – & species on Galapagos Archipelago. These facts origin (especially latter) of all my views' (Darwin in de Beer 1959, 7). Although we must not take the last sentence literally – the Galapagos experience was not exclusively relevant – we can see from this entry that the Galapagos experience was highly important for his theory-building. Darwin's *Ornithological Notes* (1835) and his *Red Notebook* (1836) show that already during the *Beagle* voyage he had considered that species might not be stable. However, only after his voyage and when his colleagues helped him to interpret his findings did he start the systematic search for evidence that species are changeable.[10]

Darwin's philosophy of science

From the start, methodological reflections informed the process by which Darwin developed his theory and looked for evidence to substantiate it. As I have already noted, he was fascinated by Herschel's philosophy of science, and he both knew William Whewell personally and was familiar with several of his works.[11] Herschel and Whewell both stressed the importance of induction and deduction for gaining scientific knowledge. Science has to discover natural laws of different degrees of generality and to discover the true causes (*verae causae*) in Newton's sense, 'that is, causes recognized as having a real existence in nature, and not being mere hypotheses or figments of the mind' (Herschel 1966, 144). For detecting such causes, analogy is central:

> If the analogy of two phenomena be very close and striking, while, at the same time, the cause of one is very obvious, it becomes scarcely possible to refuse to admit the action of an analogous cause in the other, though not so obvious in itself. (Herschel 1966, 149)

A 'true statement of any law of nature' is characterized by its requirement 'that the facts observed must follow from it as necessary logical consequences, and *this*, not vaguely and generally, but with all possible precision in time, place, weight, and measure' (1966, 25). That is, it must allow for quantification and prediction.

In a narrow sense prediction means the forecasting of future events. The preconditions for this are a theory and antecedent conditions. In a larger sense this notion is also applicable independently of time relations. By prediction one can also mean an inference from premises to something which can be expected, to already existing phenomena still to be discovered. These are non-deductive inferences. Subsequently one has to decide, by experience or other evidence, whether or not the prediction holds. Examples are the prediction of the existence of rudiments in an organism on the basis of its history of descent,

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[10] See also Sulloway 1982, Kohn and others 2006.
[11] See also Hull 1995, Ruse 1975.

the inference of the function of an organ on the basis of its structure, the inference from bones of the organism to whom they belonged and from the form of an organism of the environment in which it lives. Charles S. Peirce (1839–1914) calls such inferences 'hypotheses', 'abductions' or 'retroductions' (Peirce 1960), a procedure which is also at the basis of circumstantial evidence.

For Whewell the strength of a scientific theory consists in the possibility of its explaining phenomena drawn from quite different sets of facts. Whewell coined for this the phrase '*Consilience of Inductions*', meaning that 'inductions from classes of facts altogether different have thus *jumped together*' (1840, 2: 230). In the case of such Consilience of Inductions we have the 'best established theories which the history of science contains'. Whewell mentions the theory of universal gravitation and the wave theory of light as examples of this Consilience. Analogy as well as consilience of inductions, although he does not use this phrase, plays a central role in Darwin's logic of discovery, and he also uses the term '*vera causa*'. Darwin conceives natural selection by analogy to artificial selection; again and again he emphasizes the explanatory and integrative power of his theory and judges hypotheses and theories according to these capacities.

Already in his notebooks Darwin views the advantage of the discovery of natural laws in their explanatory, predictive and systematizing possibilities. The strategy he pursues is to build a hypothesis by induction and to apply it afterwards to other phenomena in order to see whether these other phenomena can be explained by them. But the first step, the explanation of many single phenomena, is done in the light of a question or of some kind of hypothesis or theory. Although in his autobiography Darwin claims that in his first notebook he 'worked on true Baconian principles, and without any theory collected facts on a wholesale scale [. . .], by printed enquiries, by conversation with skilful breeders and gardeners, and by extensive reading' (Darwin 1969, 119), this can only mean, as Michael Ghiselin has also pointed out, that Darwin did not yet have a hypothesis about the *mechanism* of evolution (Ghiselin 1969, 33). It cannot mean that he simply collected facts blindly. According to Darwin 'all observation must be for or against some view if it is to be of any service!' And he rejects the view that the function of a naturalist is to 'go into a gravel-pit and count the pebbles and describe the colours' (Burkhardt and others 1994 [1861], 9: 269). Darwin also adheres to the parsimony principle, according to which no more entities are to be presupposed than necessary.

Special creation as a 'limited view' of God

The idea of the fixity of species also reflects a limited view of God's power. 'Has the Creator since the Cambrian formations gone on creating animals with same general structure. – miserable limited view. –' (B 216 in Barrett and others 1987, 224)

> Astronomers might formerly have said that God ordered, each planet to move in its particular destiny. – In same manner God orders each animal created with certain form in certain country, but how much more simple, & sublime power let attraction act according to certain laws such are inevitable consequen [*sic*] let animal be created, then by the fixed laws of generation, such will be their successors. – (B 101 in Barrett and others 1987, 195)

Referring to Auguste Comte's law according to which the human mind has to go through three stages, the theological, the metaphysical and the positive, Darwin writes: 'M. Le Comte's idea of theological state of science, grand *idea* [. . .]. Zoology itself is now purely theological. –' (N 12 in Barrett and others 1987, 566–67).

It should be emphasized that it was not Darwin's aim to resolve final metaphysical and theological questions or even to prove the non-existence of God. According to Darwin man, with his fallible intellect, is not at all capable of doing this. Darwin was interested in discovering the 'laws of life', the laws of the 'origination of fresh species', to use Herschel's phrase, or, as Darwin expressed it later in his title, of the 'origin of species'.

Darwin's research programme – the search for secondary causes

Darwin's aim is to put the explanation of the origin of species and adaptations on a scientific basis, that is, to find secondary causes or secondary laws to explain them. The biblical doctrine of special creations shows considerable defects. For Darwin there are too many phenomena in nature which cannot be explained by it and it has no predictive power. It also cannot group phenomena within a general explanatory system.

The study of organisms had to be theorized at the level already reached in the sciences of physics and astronomy, to explain phenomena and processes of the living nature by natural laws instead of by the direct intervention of God. And these laws – this is the young Darwin's assumption when be begins to write his notebooks – bear God's stamp. Darwin orients himself to his colleagues in natural theology from the sciences of inanimate nature where one already supposes that God acts by natural laws. Darwin's prestigious contemporaries, teachers or friends like Herschel, Whewell, Lyell and Gray did not reject the idea that God governs the world by laws; quite the contrary, as we shall see.

Darwin's refutation of the doctrine of special creation and the plea for secondary laws is the recurrent subject of his notebooks, early *Sketch* and *Essay*, and of his *Origin of Species*.

In Herschel's and Whewell's writings the idea of natural laws in physics and astronomy plays an important role. Herschel's *Preliminary Discourse on the Study of Natural Philosophy* (1830), as well as his letter to Lyell of 20 February 1836 and his *Physical Geography* (1861), show this. A quotation from Whewell's Bridgewater Treatise *Astronomy and General Physics Considered with Reference to Natural Theology* (1833) is one of the epigraphs on the flyleaf of Darwin's *Origin of Species*. In it, Whewell, pointing to Newton and Bacon, emphasizes the role of laws in nature. He quotes from Herschel, whom he places 'among the worthiest disciples of the school of Bacon', Article 27 of the *Study of Natural Philosophy* and stresses that

> The Divine Author of the universe cannot be supposed to have laid down particular laws, enumerating all individual contingencies, which his materials have understood and obey – this would be to attribute to him the imperfections of human legislation; – but rather, by creating them endued with certain fixed qualities and powers, he has impressed them in their origin with the *spirit*, not the letter of his law, and made all their subsequent combinations and relations inevitable consequences of this first impression. (Whewell 1836, 358)

According to this view, science, 'while it discloses to us the mode of instrumentality employed by the Deity, convinces us, more effectually than ever, of the impossibility of conceiving God's actions by assimilating them to our own' (1836, 361). 'In our conceptions of the Divine purpose and agency' we must 'go beyond the analogy of human contrivances.' (1836, 360). In the preceding section, Whewell discusses 'the great authority of Bacon' and his warning against the mixing of final causes and physical enquiries. 'Final causes are to be excluded *from physical enquiry*; that is, we are not to assume that we know the objects of the Creator's design, and put this assumed purpose in the place of a physical cause.' This means, for instance, that 'we are not to think it a sufficient account of the clouds that they are for watering the earth (to take Bacon's examples) or "that the solidness of the earth is for the station and mansion of living creatures" ' (1836, 352–3). Bacon's method, pursued by Herschel and Whewell, is exactly the one Darwin follows, as we shall see, but only up to a certain point. Whewell goes on to say that it is precisely because the physical philosopher 'has thus established his theories independently of any assumption of an end, that the end, when, after all, it returns upon him and cannot be evaded, becomes an irresistible evidence of an intelligent legislator' (1836, 353). Here Darwin's will depart from Herschel's and Whewell's way, as we will see.

To fully understand the revolutionary character of Darwin's achievement it is important to know how he interpreted his evolutionary views with respect to natural theology. When Darwin started to write his notebooks he was thinking within the framework of natural theology, in which he had been trained at Cambridge. However, from the very beginning there was one big difference between Darwin and the proponents of natural theology: the authors of the *Bridgewater Treatises* wanted to prove the existence and attributes of the first cause by investigating secondary causes in nature, the means by which God works. The emphasis of Darwin's interest, however, was different. His primary aim was to resolve a scientific problem and he was focused on the secondary causes without worrying about whether this would also strengthen the assumption of a first intelligent cause.

A careful reading of Darwin's notebooks reveals that early on he abandoned the idea that scientific argumentation required God as a prime cause. Darwin's *Abstract* on John Macculloch's *Proofs and Illustrations of the Attributes of God* (1837), which he wrote after reading Malthus, is revealing here. Reading Thomas R. Malthus' *Essay on the Principle of Population* (6th edn 1826) on 28 September 1838 'it at once struck' him how selection, the 'keystone of man's success in making useful races of animals and plants', [. . .] could be applied to organisms living in a state of nature [. . .]. Here, then, I had at last got a theory by which to work' (Darwin 1969, 119–20).

In his work Malthus pointed to the discrepancy between the increase in an arithmetical ratio of the means of subsistence (1, 2, 3, 4, 5, 6) and the increase in a geometrical ratio of the human species (1, 2, 4, 8, 16, 32), when unchecked. Since human populations exhibit stability, however, there must exist a mechanism which limits this increase. Malthus assumed the constant effect of preventive checks (late marriage or restraint from marriage) and positive checks (common diseases and epidemics, wars, pestilence, plague, famine), which lead to this stability (Malthus 1989, 1: 16–18). For Malthus this principle of population is a natural law imposed by God for the wellbeing of his creatures and can be recognized

by revealed and natural religion. Referring to Malthus' reflections on the geometrical increase of population, Darwin notes:

> One may say there is a force like a hundred thousand wedges trying force <into> every kind of adapted structure into the gaps <of> in the oeconomy of Nature, or rather forming gaps by thrusting out weaker ones. <<The final cause of all this [*sic*] wedgings, must be to sort out proper structure & adapt it to change. – to do that, for form, which Malthus shows, is the final effect, (by means however of volition) of this populousness, on the energy of Man>> (Notebook D 135e in Barrett and others 1987, 375–76)

'It is a beautiful part of my theory', writes Darwin in his notebook E, that domesticated races 'are made by precisely same means as species – but latter far more perfectly & infinitely slower' (Notebook E 71 in Barrett and others 1987, 416).

In notebook E, which Darwin writes along the lines of his new Malthusian views, we find an unambiguous hint of Darwin's enthusiasm for the idea of secondary causes or laws. Reading Herschel's letter to Lyell of 20 February 1836, which was printed by Charles Babbage, Darwin writes in E 59: 'Babbage 2^{d} Edit, p. 226. – Herschel calls the appearance of new species. the mystery of mysteries. & has grand passage upon problem.! Hurrah – "intermediate causes"' (Barrett and others 1987, 413). Darwin considers these speculations of the authority of natural philosophy as an additional support and authorization of his view that species come into being by natural laws, and not by a special divine creation.

While writing notebook E in the light of his Malthusian views, Darwin wrote an *Abstract* of John Macculloch's *Proofs and Illustrations of the Attributes of God. From the Facts and Laws of the Physical Universe; being the Foundation of Natural and Revealed Religion* (1837), testing the philosophical implications and significance of his theory. This abstract, which is a critical discussion of Macculloch's argument from design, elucidates unambiguously Darwin's parting from the idea of a special creation towards a law-bound approach to explanation. Darwin does 'not want to deny laws. – The whole universe is full of adaptations. – but these are, I believe, only direct consequences of still higher laws.' Darwin does not believe that 'the pappus of [. . .] any one seed [. . .] was DIRECTLY *created*. for transportation' (53^{r} in Barrett and others 1987, 632). He rejects the idea of a special creation in favour of laws by which species and the adaptations of organisms come into being and he names his theory 'my theory of gain of small advantages' (53^{v} in Barrett and others 1987, 633).[12] Darwin also rejects the 'explanation of types of structure in classes – as resulting from the *will* of the deity, to create animals on certain plans.' He does this for *methodological* reasons arguing that this is no explanation. The argument that follows can hardly be overestimated in its historical importance. For him this explanation

> *has not the character of a physical law*, <<& is therefore utterly useless – it foretells nothing>> because we know nothing of the will of the Deity. how it acts &

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[12] The transcription should be most likely 'grain' of small advantages instead of 'gain'. Barrett in Gruber and Barrett 1974 writes 'grain', and Darwin himself uses 'grain' several times in his writings; see Engels 2007, 72.

> whether constant or inconstant like that of Man. – the cause given we know not the effect. (55[r] in Barrett and others 1987, 634–35)

We have heard that in the natural theological framework 'science, in a sense, *was* religion' (Browne 1995, 129). This means on the other hand that it was not only justified but obligatory to subject natural theological argumentation to the methodological standards of good science. And the best philosophy of science which Darwin knew was Herschel's, laid down in his *Preliminary Discourse on the Study of Natural Philosophy*.

Darwin's argument, however, implies much more than might be assumed at first sight and perhaps more than Darwin himself was aware of. His methodological caveat that the argument from the will of the deity lacks the character of a physical law because it allows neither explanation nor prediction hits not only the *special creation-variant* of natural theology but also its *natural law variant*: since we know nothing of God's will – whether it acts constantly or intermittently, like that of man – we cannot know God's laws, we cannot even know *if* there are divine laws at all. Darwin's spectacular entry is an expression of his incipient agnosticism. And this agnosticism is based on *methodological considerations*: in science we must not rely on our image of God, because we actually don't know him. But moreover it expresses a scepticism about the character of God: Darwin doesn't exclude that God's will is as intermittent as that of man!

Darwin's scepticism also manifests itself in remarks on his usage of the term 'final cause'. At the beginning he uses this term in his notebooks as a matter of course and even after having read Malthus and after having discovered how selection can work under natural conditions, he uses teleological language: 'The final cause of all this [*sic*] wedgings, must be to sort out proper structure & adapt it to change' (D 135e in Barrett and others 1987, 376). In his *Abstract* on Macculloch's *Proofs* he however reflects: 'The Final cause of innumerable eggs is explained by Malthus. – [is it anomaly in me to talk of Final causes: consider this! –][CD] consider these barren Virgins' (58[r] in Barrett and others 1987, 637).[13] Darwin becomes aware that he is using a notion which belongs to a framework that he cannot share any more. Therefore he admonishes himself to 'consider these barren Virgins'. Talking of final *causes* in the context of his new theory in fact *is* an anomaly, because in the strict sense it no longer fits into the new theoretical context. As soon as Darwin constructed his theory, he gave up the idea of a Divine creator in the sense of a constitutive part of it. From then on Darwin's use of notions like 'final causes' and 'Creator' in the context of natural science cannot be taken literally, but is rather a *façon de parler*. Nevertheless Darwin transports attributes of the creator into his new paradigm, like the idea of a perfect adaptation, which presupposes an almighty, omniscient and infinitely good God. However, Darwin is aware of the problems of perfect adaptation and later on he retreats to a relative adaptation.[14]

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[13] Barrett has a question mark instead of an exclamation mark after 'consider this' (see Barrett in Gruber and Barrett 1974, 419).

[14] See the discussion in Ospovat 1979, 1981 and von Sydow 2005.

The structure of Darwin's theory of descent with modification through variation and natural selection

Darwin's *Origin of Species* is framed by references to the creator. Two epigraphs, one by Whewell and one by Bacon, decorate the frontispiece. From the second edition on, an epigraph by Bishop Joseph Butler is added between them. The first one is taken from William Whewell's *Bridgewater Treatise on Astronomy and General Physics Considered with Reference to Natural Theology* (1833): 'But with regard to the material world, we can at least go so far as this – we can perceive that events are brought about not by insulated interpositions of Divine power, exerted in each particular case, but by the establishment of general laws.' The second quotation is taken from Bishop Joseph Butler's *The Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature* (1736). 'The only distinct meaning of the word "natural" is *stated*, *fixed*, or *settled*; since what is natural as much requires and presupposes an intelligent agent to render it so, *i.e.*, to effect it continually or at stated times, as what is supernatural or miraculous does to effect it for once.'

The third one is taken from Francis Bacon's *Advancement of Learning* and has already been cited.[15] Bacon defends the idea of God as the first cause who 'worketh nothing in nature but by second causes' and he defends a thorough study of natural philosophy as an antidote against atheism. Whereas 'a little or superficial knowledge of Philosophy may incline the mind of man to Atheism, but a further proceeding therein doth bring the mind back again to Religion' (Bacon 2001, 9).[16]

In the final chapter of the *Origin* Darwin writes:

> To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to *secondary causes*, like those determining the birth and death of the individual. When I view all beings not as special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Cambrian system was deposited, they seem to me to become ennobled. (1988a, 445–46; my emphasis)

And the book closes with the famous passage:

> Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator 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. (1988a, 446–47; 'by the Creator' was added from the second edition on).

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[15] See the section 'The "mystery of mysteries" – the "origination of fresh species"' above.

[16] In the first edition of 1605 he writes: 'Undoubtedly a superficial tincture of philosophy may incline the mind to atheism, yet a further knowledge brings it back to religion' (Bacon 1901 [1605], 28).

Darwin had used almost the same formulations in his *Essay* of 1844, a shorter version of his *Origin*. His readers could get the impression that in the *Origin* Darwin was in fact carrying out the programme of natural theology as laid down in Whewell's *Bridgewater Treatises*.

Darwin names his theory 'theory of descent with modification, through variation and Natural Selection' (1988a, 421).[17] He takes it for granted that there is an analogy between the origin of new races of plants and animals by artificial selection and that of new species in nature. In artificial selection four elements are involved: 1. *individual variation* among organisms of a race, 2. the conscious, intentional *selection* of certain individuals for breeding, 3. the *inheritance* of many of their traits, 4. the prevention of crossing back by *reproductive isolation*. Breeders choose those individuals of a race which have certain traits or characters useful for the breeders' purpose (artificial selection) and let them propagate. In the course of many generations the traits, insofar as they can be inherited, gradually prevail or take the form intended by the breeder. In order to maintain these traits it is necessary to avoid the crossing of these individuals with others which lack them. '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 have made for himself useful breeds' (Darwin 1988a, 23).

In nature there is an analogous mechanism where, however, the traits are purposive for an organism itself in a certain environment. Darwin proceeds from the observation that two organisms of the same species are never completely identical. There are always variations, however small, and thus also differences in adaptation to an environment. Those organisms which with respect to the exigencies of survival are better adapted because of their traits, that is, more purposively outfitted than their conspecifics, have higher chances of survival and can more successfully reproduce than the others. This means that a natural selection of the better adapted takes place. Those traits which are advantageous for survival can accumulate during generations by inheritance and thus increasingly change, compared to the traits of the aboriginal stock. This gradual process leads to the emergence of new varieties and eventually to that of new species. Natural selection not only leads to the dying out of species but also fulfils the *constructive* function of bringing forth *new species*. As opposed to artificial selection, however, there is no breeder in nature who purposively chooses organisms for propagation. In order to explain the process of *natural* selection in place of the human breeder there has to be a nonpersonal empirical mechanism fulfilling the function of selection. Here Darwin leaves the analogy between artificial and natural selection, because their causes are different. Darwin names this natural mechanism the 'struggle for life' or 'struggle for existence' and draws upon Malthus' principle of population with its idea of discrepancy between the arithmetic ratio of the means of subsistence and the geometrical ratio of population increase (Darwin 1988a, 52–58).

> Hence, as more individuals are produced than can possibly survive, there must in every case be a Struggle for Existence, either one individual with another of

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[17] Initially (1859) he used the phrase 'theory of descent with modification through natural selection' (Darwin 1964, 459).

> the same species, or with the individuals of distinct species, or with the physical conditions of life. It is the doctrine of Malthus applied with manifold force to the whole animal and vegetable kingdoms; for in this case there can be no artificial increase of food, and no prudential restraint from marriage. (Darwin 1988a, 52–53)

It is important to note that the scarcity in resources is only one of many causes of this many times misunderstood 'struggle for life'. In this struggle 'a grain in the balance may determine which individuals shall live and which shall die' (Darwin 1988a, 428).

Darwin incorporated the critical reception of his work into the new editions. Particularly his metaphors 'natural selection' and 'struggle for existence' or 'struggle for life' were subject to much misunderstanding. He emphasizes that he uses the term 'struggle for existence' in 'a large and metaphorical sense' (1988a, 52). At least five different meanings may be ascribed to this phrase: 1. the competition among individuals of the same species (intraspecific competition); 2. the competition between individuals of different species (interspecific competition); 3. the struggle for existence of an individual against environmental dangers (drought, coldness, wetness, etc.); 4. the need to leave progeny; and 5. the dependence of individuals on each other. The phrase 'struggle for existence' has often been interpreted as a bloody fight between individuals, races or species for food. The situation of scarcity of food described by Malthus, however, does not necessarily imply a violent war or fight but allows for different strategies of problem solving, and moreover it is not typical for all situations of this struggle for life. It can also be faced by *cooperation* instead of competition. This is a line of reception which was pursued particularly in the Russian Darwin-reception by Peter Kropotkin and others (see Todes 1989). In his correspondence with Wilhelm Preyer, Darwin also thematizes the problem of translation of this phrase. In his letter of 29 March 1869 he writes:

> I have always felt some doubts, but was unable to draw any distinct line between the two ideas therein included. I suspect that the German term, Kampf etc, does not give quite the same idea. The words 'struggle for existence' express, I think, exactly what concurrency does. It is correct to say in English that two men struggle for existence who may be hunting for the same food during a famine, and likewise when a single man is hunting for food; or again it may be said that a man struggles for existence against the waves of the sea when shipwrecked. (Darwin 1869)

The term 'concurrency' has a double meaning. It can mean 'competition' as well as 'cooperation'. The term 'natural selection' was misconstrued as well, and some 'objected that the term selection implies conscious choice in the animals which become modified'. Others argued that he speaks 'of Natural Selection as an active power or Deity' (Darwin 1988a, 66). There was also the reproach of inconsistency concerning the role of design in nature. Some readers felt encouraged to attribute intelligent choice to nature. Alfred Russel Wallace ascribed this to Darwin's analogy between artificial and natural selection (see Burkhardt and others 2004 [1866], vol. 14, Introduction). Darwin replied that metaphors are widely used in other sciences too without misunderstanding their meaning. As an example he mentions the term 'elective affinities' of the various elements in chemistry; 'and yet an acid cannot strictly be said to elect the base with which it

in preference combines' (1988a, 66). Wallace suggested that Darwin substitute the expression 'natural selection' for Herbert Spencer's term 'survival of the fittest'. Darwin did not replace the term, but from the fifth edition on he also used the term 'survival of the fittest' introduced by Spencer in his *Principles of Biology* (Spencer 1864, 1: 444f.), who in turn construes it in the sense of Darwin's term 'natural selection'. Spencer thinks of an equilibrium between an organism and its environment which can be fulfilled in different degrees, better or worse. The notion 'fit' serves to describe this equilibrium: '. . . those will survive whose functions happen to be most nearly in equilibrium with the modified aggregate of external forces' (1864, 1: 444). Contrary to much misunderstanding and misinterpretation it also has to be stressed that for Darwin the unit of selection, that is, the object upon which natural selection acts, is the individual with its particular traits in a specific environment.

For the possibility of the origin of species further conditions must be fulfilled: back crossing must be prevented because otherwise traits cannot be fixed. Conditions for reproductive isolation are necessary. Moreover it has not yet been explained how from one species several new species can originate. 'This problem is the tendency in organic beings descended from the same stock to diverge in character as they become modified' (Darwin 1969, 120). Under the pressure of natural selection not only one but several species can evolve from one and the same stock in adaptation to different ecological niches. For the evolution of 'divergence of characters' and the possibility of reproductive isolation, the Galapagos Archipelago was an exemplary laboratory.

From these individual variants in the course of time hereditary varieties, subspecies and finally new species evolve. Darwin advocates a *gradualism* and draws on the principle of continuity of natural philosophy and he claims that the old principle '*natura non facit saltum*' (nature makes no leaps) is now rendered intelligible by his theory (Darwin 1988a, 431).

Darwin underlined several times in his books and his correspondence that he did not claim to explain the origin of life or the origin of mind (1988a, 214).[18] 'These are problems for the distant future, if they are ever to be solved by man' (1989, 21: 70). Statements like these encouraged much criticism from his opponents (Owen 1860, Whewell in Todhunter 1876).

To sum up: the origin of new species is for Darwin the result of a complex interaction of the external conditions of life and the internal structure of organisms, which is subject to natural laws and conditions of different kinds (law of natural selection, laws of variation and inheritance, etc.), even if some of them were not yet known at Darwin's time. Darwin wrote several times that variations happen 'spontaneously' or 'by chance', meaning that we do not yet know their laws. Although Darwin did not yet know the laws of variation and had incorrect ideas about inheritance from today's point of view, the *structure of his theory* with the elements of *variation*, *natural selection* and *inheritance* is still valid.

The arguments collected by Darwin in his *Origin* back each other up. It is not only the principle of natural selection associated with his name, but the whole

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[18] See also Burkhardt and others 8: 153f., 11: 278.

complex of his theoretical assumptions and disciplines (morphology, embryology, phylogeny, paleontology and others) to which today the phylogenetic reconstruction by molecular-biological methods is added, serving to corroborate Darwin's theory. Darwin was able to explain consistently the results of these different disciplines and answer questions which up to then had been puzzles. He could explain the existence of rudiments, the unity of type in the different classes of vertebrates, the similarity between their embryos and other phenomena. Darwin applies the hypothetical-deductive method also to creationism and shows that the assumptions that have to be derived from it do not correspond to experience. Moreover, many phenomena which creationism cannot explain and which are anomalies for the creationist assumption of special creation are explicable by Darwin's theory. Darwin draws upon arguments from philosophy of science by pointing to the lack of explanatory and prognostic force of the doctrine of special creation.

In his writings Darwin was, however, silent about the philosophical and theological application of his theory, as Asa Gray (1963) noted. In *Origin* he restricts his criticism of the doctrine of special creation to methodological issues. By only reading *Origin*, which begins with the three natural theological epigraphs of Whewell, Butler and Bacon, and which, from the second edition on, ends with a reference to the creator, one could have been excused for thinking that this work is written in accordance with the idea that God created the 'law' described by Darwin in his theory of descent with modification through variation and natural selection. The detailed discussion of the philosophical and theological implications was carried on behind the scene of his publications, in his extensive correspondence on these issues. Yet on the last two pages of the second volume of *Variations* we find a short, but profound discussion of his meaning of the word 'accidental', even though he was 'aware that I am travelling beyond my proper province' (Darwin 1988b, 2: 371). Darwin writes this in response to Gray's proposal to include intelligent design in the production of variations. We will come to these issues later, in the section 'Reactions – Attempts of conciliation and reconciliation of Darwin's theory with teleology'.

Darwin's revolutionary challenge – teleology without telos

Darwin's hints in his early notebooks, as well as his extensive correspondence on the question of the theological interpretation of his theory, show that he not only rejected the biblical version of natural theology but also its *natural law version*. Darwin's laws are such that he can explain by them the origin of species as well as of adaptations, that is expediency, without presupposing an intelligent first cause. Initially Darwin had started with the intention of providing for the sciences of living nature the connection to the other natural sciences and of discovering God's natural laws of the origination of fresh species. Very soon he realizes that the hypothesis of God, of an intelligent first cause, is dispensable for such an explanation. This does not mean, as already said, that Darwin claims to be able to explain the origin of life as such. However, the hypothesis of a metaphysical intelligent cause is no more convincing than that of matter as the beginning of everything. Darwin also applies the methodological principle of parsimony to the hypothesis of God. The assumption of a God has no additional explanatory and predictive value for biology. The phenomena of life cannot be explained

better by it than without it; quite the opposite: it causes more problems because it brings about more questions than answers. Also the problem of theodicy, the question of how the assumption of a beneficent, omniscient and almighty God can be justified in the face of suffering and misery in the world is dissolved, because in Darwin's view of nature suffering as well as happiness were to be expected. Nothing is perfect in nature, but all in all, organs work well enough to enable organisms to live. The presupposed blindness of this process and its explanatory superiority implied a provocation for natural theology.

Therefore it was misleading for Darwin to have decorated the beginning of his *Origin* by epigraphs taken from Whewell, Butler and Bacon, as if these were leading motives for pursuing a programme of natural theology. Darwin's revolution is one in the philosophical foundations of biology.

Reactions – the 'law of higgledy-piggledy'

Darwin ordered the publisher John Murray to send copies of his book directly to his teachers and others who had influenced him. In his letter to Sir John Herschel of 11 November 1859, Darwin writes that he has 'taken the liberty of directing Murray' to send Herschel a copy of his book on the *Origin of Species* and that he 'cannot resist the temptation of showing in this feeble manner' his 'respect, & the deep obligation', which he owes to Herschel's *Introduction to Natural Philosophy* (Burkhardt 1991 [1858–59], 7: 370–1). As I have pointed out, Darwin had followed Herschel's track in more than one respect. Darwin thought that by his theory he had found the answer to Herschel's great question, that he had resolved the 'mystery of mysteries' and discovered the 'vera causa' of the origin of species. He was incredibly disappointed when he heard by a 'round about channel' that Herschel said that his book was 'the law of higgledy-pigglety' (*sic*). 'What this exactly means', Darwin wrote to Lyell on 10 December 1859, 'I do not know, but it is evidently very contemptuous. – If true this is great blow & discouragement' (Burkhardt 1991 [1858–59], 7: 423). In 1861 Herschel sent Darwin his *Physical Geography*. His remarks on Darwin's *Origin of Species* in a footnote are no less contemptuous than his previous ones.

> We can no more accept the principle of arbitrary and casual variation and natural selection as a sufficient account, *per se*, of the past and present organic world, than we can receive the Laputan method of composing books (pushed *a* [*sic*] *l'outrance*) as a sufficient one of Shakespeare and the Principia. Equally in either case, an intelligence, guided by a purpose, must be continually in action to bias the direction of the steps of change – to regulate their amount – to limit their divergence – and to continue them in a definite course. We do not believe that Mr. Darwin means to deny the necessity of such intelligent direction. But it does not, as far as we can see, enter into the formula of the law; and without it we are unable to conceive how the law can have led to the results. (*Note added* Jan. 1861) (Herschel 1861, 12)

The 'Laputan method' is, of course, an allusion to Jonathan Swift's *Gulliver's Travels*. One of his ports of call is the island of Laputa with its grand Academy of Lagado. A professor demonstrates a frame with bits of wood linked together by slender wires to which iron handles are attached. On every square of wood words are written. The students give the wires a sudden turn so that the whole order of the words changes. Each time they do this the words are read and if some of them

fit together to make a sentence they are written down in a book. The idea is to provide a complete body of all arts and sciences by this method. Herschel reduces Darwin's theory to a caricature by his comparison with the 'Laputan method of composing books'. The message is: it is as improbable that this method can produce meaningful books like the works of Shakespeare and Newton as it is that little organisms with organs adapted to their functions can come into being. On the other hand, Herschel does not mean to deny that an intelligence, who is guided by a purpose, 'may act according to a law' (that is to say, on a pre-conceived and definite plan). He was the one who had proposed to disclose the mystery of mysteries by intermediate causes.

> Such law, stated in words, would be no other than the actual observed law of organic succession; or one more general, taking that form when applied to our own planet, and including all the links of the chain which have disappeared [. . .]. Granting this, and with some demur as to the genesis of man, we are far from disposed to repudiate the view taken of this mysterious subject in Mr. Darwin's work. (*Note added* Jan. 1861) (Herschel 1861, 12)

This however means that Herschel rejected the very essence of Darwin's theory as Darwin himself understood it. The origin of the human being fell for Darwin under the same law of blind variation and natural selection as every other species.

William Whewell, author of the first epigraph of Darwin's *Origin*, refused to allow a copy of the book to be placed in the library of Trinity College, thus dissenting 'in a practical manner for some years' (Darwin 1887, 2: 261n). We can only speculate about his reasons: the provocation or even more the affront lay in Darwin's law which went beyond human contrivance but also beyond that of the Divine Author. According to Herschel and to Whewell, who quotes Herschel, God has impressed the material world with the *spirit* of his laws. But if God has created an evolutionary law like that discovered by Darwin and articulated in his theory, a law characterized by Herschel as the 'law of higgledy-piggledy', then God had deprived *himself* of the attributes of an omnipotent, all-wise and benevolent creator: the laws work in such a way that the specific outcome is not in view in advance, that there is no goal and no specific direction. So the special attributes of these laws do not only question God's omnipresent interference in nature, but they also undermine the meaning of his very existence as a *creator* of species. Darwin had formulated a law not worthy of God (see also Hull 1983, 61). Also 'the absence of any conceivable natural beginning leaves room for, and requires, a supernatural origin. Nor do Mr Darwin's speculations alter this result.' Whewell articulates this criticism in a letter to Reverend Prof. Dr D. Brown on 26 October 1863. For when Darwin 'has accumulated a vast array of hypotheses, still there is an inexplicable gap at the beginning of the series' (Whewell in Todhunter 1876, 2: 433).

Karl Ernst von Baer, too, in his discussion of Darwinism later refers to the Academy of Lagado (1873, 1987). Adam Sedgwick's reaction was very similar and he did not stint his mockery by treating Darwin's theory like a fairy tale of science. He read Darwin's book

> with more pain than pleasure. Parts of it I admired greatly; parts I laughed at till my sides were almost sore; other parts I read with absolute sorrow; because I think them utterly false & grievously mischievous – You have *deserted* – after a start in

> that tram-road of all solid physical truth – the the [*sic*] true method of induction – & started up a machinery as wild I think as Bishop Wilkin's locomotive that was to sail with us to the Moon. (Burkhardt and others 1991 [1858–59], 7: 396)

In his answer to Sedgwick of 26 November 1859, Darwin expresses his grief at having shocked someone whom he sincerely honours. At the same time he opposes Sedgwick's criticism with a Popperian argument. Darwin doubts that his book will be mischievous 'for there are so many workers that, if I be wrong I shall soon be annihilated; & surely you will agree that truth can be known only by rising victorious from every attack' (Burkhardt and others 1991 [1858–59], 7: 403). By this argument Darwin applies his theory of selection to the history of science. Darwin 'could pretty plainly see' – and this is a Kuhnian argument – 'that if my view is ever to be generally adopted, it will be by young men growing up & replacing the old workers, & these young ones finding that they can group facts & search out new lines of investigation better on the notion of descent, that [*sic*] on that of creation' (Letter to T. H. Huxley, 2 December 1860, Burkhardt and others 1993 [1860], 8: 507). And indeed, as we will see in this work on the reception of Darwin in Europe, by Darwin's revolution quite new research programmes were opened which allowed new ways of investigation.

In the following years Darwin had a lively correspondence with leading scientists like Gray, Lyell, Herschel, Hooker, Huxley and various other persons on the argument from design and the relationship between the theory of natural section and teleology.

However, there were also affirmative reactions to Darwin's theory on the part of philosophy of science. John Stuart Mill had a correspondence on this subject with Alexander Bain, Herbert Spencer, Hewett Cottrell Watson, Edwin Ray Lankester and others in which he defends Darwin against criticism. 'Darwin has found (to speak Newtonially) a *vera causa*, and has shewn that it is capable of accounting for vastly more than had been supposed' (letter to Watson, 30 January 1869, in Mill 1972, 17: 1553–54).[19] In his *System of Logic* he defends Darwin against the accusation of violating the rules of induction:

> Mr. Darwin's remarkable speculation on the Origin of Species is another unimpeachable example of a legitimate hypothesis. What he terms 'natural selection' is not only a *vera causa*, but one proved to be capable of producing effects of the same kind with those which the hypothesis ascribes to it: the question of possibility is entirely one of degree. [. . .] It is unreasonable to accuse Mr. Darwin (as has been done) of violating the rules of Induction. The rules of Induction are concerned with the conditions of Proof. Mr. Darwin has never pretended that his doctrine was proved. He was not bound by the rules of Induction, but by those of Hypothesis. And these last have seldom been more completely fulfilled. He has opened a path of inquiry full of promise, the results of which none can foresee. And is it not a wonderful feat of scientific knowledge and ingenuity to have rendered so bold a suggestion, which the first impulse of every one was to reject at once, admissible and discussable, even as a conjecture? (Mill 1973, 498–99n)[20]

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[19] See more letters in Mill 1972, vols 15 and 16.

[20] In his later *Essays on Religion* (1874) Mill's attitude, however, is much more ambivalent (Mill 1993).

As early as 1859 the botanist Hewett Cottrell Watson was convinced that Darwin's

> leading idea will assuredly become recognized as an established truth in science, i.e. 'natural selection'. – (It has the characteristics of all great natural truths, clarifying what was obscure, simplifying what was intricate, adding greatly to previous knowledge. You are the greatest Revolutionist in natural history of this century, if not of all centuries. (21 November 1859, Burkhardt and others 1991 [1858–59], 7: 385)

Darwin's teacher and friend Henslow defended Darwin at various occasions against criticism, although he wrote to Joseph Hooker 'I do not disguise my own opinion that Darwin has pressed his hypothesis too far – but at the same time I assert my belief that his Book is (as Owen described it to me) the "Book of the Day" ' (10 May 1860, Burkhardt and others 1993 [1860], 8: 200).[21]

Reactions – attempts of conciliation and reconciliation of Darwin's theory with teleology

The renowned American botanist Asa Gray (1810–88) was Darwin's leading advocate in American science, as Huxley was in England. From 1860 on, by a series of long articles in the *American Journal of Science and Arts*, he tried to provide the possibility for a fair hearing of Darwin's arguments in America. Together with more articles the texts were later on published under the title *Darwiniana: Essays and Reviews Pertaining to Darwinism* (1876, ed. Hunter Dupree 1963). Like many of Darwin's English correspondents, Gray was deeply religious and a convinced proponent of the *argument from design*. In his article 'Natural Selection not inconsistent with Natural Theology' he ascertains that 'Mr. Darwin has purposely been silent upon the philosophical and theological applications of his theory' (Gray 1963, 118). Gray thinks that in Darwin's *Origin* a 'theistic view of Nature' is implied (1963, 119). The *scientific notions* of the theory of transmutation have to be the same for theists and atheists as this is the case with the theory of dynamics. Natural scientists shall pursue research as far as possible. But when we go further and further, at some point we reach a point where things cannot be explained any more by natural sciences. Here is the place for providence or design. For Gray the theory of descent and teleology are compatible. This manifests itself in Gray's understanding of evolution: natural selection as the scientifically explorable cause is only one component in the process of the origin of adaptations and species. The other one is the quality of the causes of variations. The origin of the variations is divine design, which gives them their specific quality and direction.

Darwin had called variations spontaneous and due to chance, but he admitted that 'this, of course, is a wholly incorrect expression, but it serves to acknowledge plainly our ignorance of the cause of each particular variation' (Darwin 1988a,

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[21] Richard Owen, however, became one of Darwin's fiercest critics (Owen 1860). 'It is painful to be hated in the intense degree with which Owen hates me' (Darwin to Lyell, 10 April 1860, Burkhardt and others 1993 [1860], 8: 154).

112). By 'chance' Darwin does not deny the existence of laws of variation but assumes that these variations are accidental, insofar as purpose is concerned.[22] Although Darwin does not yet know the causes of variations this does not mean that he allows God to fill this link. Gray on the other hand argues that 'at least while the physical cause of variation is utterly unknown and mysterious, we should advise Mr. Darwin to assume, in the philosophy of his hypothesis, that variation has been led along certain beneficial lines' (Gray 1963, 121–22). For Gray, natural selection and natural theology are compatible because he locates design or providence in the area of variations. The title 'Natural selection not inconsistent with Natural Theology' thus distracts from the real conflict, since the quality of variations is the subject of controversy, designed or not designed.

In his response to Asa Gray, Darwin singles out his assumption that variation has been led along certain beneficial lines. 'I grieve to say that I cannot honestly go as far as you do about Design.' Darwin cannot believe 'that the tail of the Fan-tail was led to vary in the number & direction of its feathers in order to gratify the caprice of a few men' (Burkhardt and others 1993 [1860], 8: 496). Also in his correspondence with Herschel, whom he thanks for his kind present of his *Physical Geography*, Darwin discusses the argument of 'intelligent Design' and raises the same objections as in his correspondence with Gray (Burkhardt and others 1994 [1861], 9: 135–36). In a letter to Charles Lyell, Darwin deplores 'that such views of Asa Gray & Herschel merely show that the subject in their minds is in Comte's theological stage of science' (Burkhardt and others 1994 [1861], 9: 226–27).

> But astronomers do not state that God directs the course of each comet & planet. – The view that each variation has been providentially arranged seems to me to make natural selection entirely superfluous, & indeed takes whole case of appearance of new species out of the range of science [. . .]. It seems to me that variations in the domestic & wild conditions are due to unknown causes & are without purpose & in so far accidental; & that they become purposeful only when they are selected by man for his pleasure, or by what we call natural selection in the struggle for life & under changing conditions. (Burkhardt and others 1994 [1861], 9: 226)

Darwin can no more believe in 'each variation that has ever occurred having been preordained for a special end [. . .] than that the spot on which each drop of rain falls has been specially ordained' (letter to Hooker, 12 July 1870, Darwin and Seward 1903, 1: 321). And he becomes very concrete when he asks Lyell if he honestly will tell him whether he believes that the shape of Darwin's nose was ordained and guided by an intelligent cause (Burkhardt and others 1994 [1861], 9: 238). Why should not the fall of a meteoric stone also be ordained and guided? Why do we explain this by the attraction of gravity? Why would one talk of theological pedantry in this case and not in the case of the formation of species? Darwin's answer is that the idea of a formation of species is novel and has hitherto been viewed as beyond law. And, we must add, his theory

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[22] Darwin's letter to Frances Julia Wedgwood, 11 July 1861 in Burkhardt and others 1994 [1861], 9: 200; see also Darwin 1988b, 371–72.

also had implications for the image of the human being as descended from animals.

In addition, the problem of theodicy haunts Darwin: there 'seems to me too much misery in the world'. He cannot persuade himself 'that a beneficent & omnipotent God would have designedly created the Ichneumonidae with the express intention of their feeding within the living bodies of caterpillars, or that a cat should play with mice'. If we reject that God has ordained this Darwin can 'see no necessity in the belief that the eye was expressly designed' (Burkhardt and others 1993 [1860], 8: 224).

On the other hand Darwin repeatedly mentions that he is 'in a complete jumble on the point',[23] 'in an utterly hopeless muddle'.[24]

> I cannot anyhow be contented to view this wonderful universe & especially the nature of man, & to conclude that everything is the result of brute force. I am inclined to look at everything as resulting from designed laws, with the details, whether good or bad, left to the working out of what we may call chance. Not that this notion *at all* satisfies me. I feel most deeply that the whole subject is too profound for the human intellect. A dog might as well speculate on the mind of Newton. – Let each man hope & believe what he can. (Burkhardt and others 1993 [1860], 8: 224)

On the last two pages of *Variation*, Darwin describes the conflict implied in the attempt to reconcile intelligent design with a law view of the formation of species also by referring to his discussion with Asa Gray.

> If we assume that each particular variation was from the beginning of all time preordained, then that plasticity of organization, which leads to many injurious deviations of structure, as well as the redundant power of reproduction which inevitably leads to a Struggle for Existence, and, as a consequence, to the Natural Selection or Survival of the Fittest, must appear to us superfluous laws of nature.' (Darwin 1988b, 372)

On the other hand, an 'omniscient Creator must have foreseen every consequence which results from the laws imposed by Him' (1988b, 371). This implies for Darwin that he also intentionally ordered the details. 'But can it be reasonably maintained that the Creator intentionally ordered, if we use the words in any ordinary sense, that certain fragments of rock should assume certain shapes so that the builder might erect his edifice?' We can go on to living nature now and ask if the creator has caused 'the frame and mental qualities of the dog to vary in order that a breed might be formed of indomitable ferocity, with jaws fitted to pin down the bull for man's brutal sport?' (1988b, 371). We cannot reasonably presuppose that an omniscient creator has foreseen and intentionally ordered all this. Otherwise he would have ordered 'superfluous laws of nature' and, one has to add, laws of nature which can lead to devastating results. But if we give up this assumption in one case and thus admit that there are laws and events in the world like the ones just described and where we have to draw upon other explanatory principles than the creator, then 'no shadow of reason can be

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[23] Burkhardt and others 1994 [1861], 9: 135.
[24] Burkhardt and others 1993 [1860], 8: 496.

assigned for the belief that variations, alike in nature and the result of the same general laws, which have been the groundwork through Natural Selection of the formation of the most perfectly adapted animals in the world, man included, were intentionally and specially guided' (1988b, 371). Admitting the one but not the other would have to assume that there are laws and events in the world which are not subject to the creator's power and foresight. What kind of omnipotence, omnipresence and beneficence would this be? To our understanding, 'an omnipotent and omniscient Creator ordains everything and foresees everything' (1988b, 372). Pressing questions are, what could be explained by a creator who established superfluous and devastating laws? How would it help us in everyday life? Where to draw the line between those results the creator wished to happen and those he is not responsible for? 'I am aware that I am travelling beyond my proper province [. . .]. Thus we are brought face to face with a difficulty as insoluble as is that of free will and predestination' (1988b, 371–72). This may be one of the reasons why Darwin finally in his autobiography described himself as an agnostic instead of a theist or atheist. 'The mystery of the beginning of all things is insoluble by us; and I for one must be content to remain an Agnostic' (1969, 94). Darwin was very sensitive to these issues and admitted that the 'theological view of the question' was 'always painful' to him. 'I had no intention to write atheistically' (Burkhardt and others 1993 [1860], 8: 224).

For Herschel as well as for Lyell, who had always encouraged Darwin to publish his theory although he had reservations against the idea of transmutation of species and accepted it only very late and never as radically as Darwin, a particular stumbling block was the idea that the human being had gradually evolved from other animals (see Engels 2007, 136). According to Darwin, man also owes his existence to blind mechanisms of evolution and not to any godly act of separate creation. Thus in nature he is no exception. A second source of provocation which seemed no less threatening to many of Darwin's contemporaries was the assumption that mankind had 'apelike progenitors'. No matter how large the difference between man and other animals may be, it is certainly 'one of degree and not of kind', Darwin writes (1989, 21: 130; also 69–70). For this reason, Darwin assigns mankind a place in the animal kingdom (1989, 21: 152). But this is only *one* aspect of the human being. Without being able to go into details here it must be emphasized that Darwin's *Descent of Man* contains chapters where he works out a *distinctive human trait* which no other animal has: man's faculty of being a *moral* being, based on the *moral sense* or *conscience*. Moreover, for Darwin religion has an enormous impact on the development of a moral culture (Engels 2006, 2007).

There were also other views of the compatibility of Darwin's theory and teleology. Examples are his son Francis Darwin, Thomas Henry Huxley and the German philosopher Christoph Sigwart. According to Huxley (1869) 'the most remarkable service to the philosophy of Biology rendered by Mr. Darwin is the reconciliation of Teleology and Morphology, and the explanation of the facts of both which his views offer'. By 'teleology' he does not mean the explanation of purposeful structures by final causes, which received the 'death-blow', but 'a wider Teleology' based on the fundamental propositions of evolution (Huxley 1968b, 110). Although Huxley was Darwin's leading advocate in England he by no means agreed with all of Darwin's assumptions. He rejected for instance

Darwin's strict gradualism expressed by the principle of continuity '*Natura non facit saltum*', claiming that 'Nature does make jumps now and then' (Huxley 1968a, 77). For Francis Darwin there is no conflict between teleology and religion with the doctrine of evolution, because 'the doctrine of Evolution is neither Antitheistic nor Theistic. It simply has no more to do with Theism than the first book of Euclid has' (Darwin 1887, 2: 202). 'The doctrine of Evolution, therefore, does not even come into contact with Theism, considered as a philosophical doctrine. That with which it does collide, and with which it is absolutely inconsistent, is the conception of creation, which theological speculators have based upon the history narrated in the opening of the book of Genesis' (Darwin 1887, 2: 203).

Christoph Sigwart is another example showing how the philosophical implications of Darwin's ideas were quickly picked up in Europe. For Sigwart the general importance of the Darwinian movement is the reconciliation of the mechanical view of organisms with the recognition of purposiveness. The existence of purposiveness of organisms now can be recognized without shame because it is possible to explain it by general laws. Today we 'can only call it prudery based on misunderstanding that it was fashionable for some time to judge already the mentioning of the word purpose as scientifically indecent' (Sigwart 1889, 50).[25] Indeed, many German scientists and thinkers appreciated Darwin's theory because of its explanatory and unifying power.[26] For many Darwin had shown how a scientific explanation of the formation of species and purposiveness might be possible even if the principle of natural selection was not convincing for them.[27]

These are examples of the dynamic of exchange between Darwin and his reception which was typical for Darwin during his whole life. Darwin was a prime example for the fruitful intellectual exchange between an author and his reception.[28] He incorporated the reactions to his works into his new editions by learning from them or by critically discussing them. Darwin was a very attentive 'receiver' of the reception of his works.

In the rest of the book it will be shown how these themes were revisited as that dynamic extended to Europe.

Conclusion

Summarizing the arguments exchanged by Darwin and his critics, we come to the conclusion that it was not Darwin who had left the 'tram-road of all solid physical truth' but those who kept defending the idea of an intelligent

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[25] 'Sobald man sich dieß [*sic*] vergegenwärtigt, kann man es nur als eine auf Misverstand [*sic*] beruhende Prüderie bezeichnen, wenn es eine Zeit lang Mode war, auch nur die Nennung des Wortes Zweck für wissenschaftlich unanständig zu halten.' (Sigwart 1889, 50).

[26] See for instance the chapters by Mario Di Gregorio (Chapter 4) and Helmut Pulte (Chapter 6) in this volume.

[27] For the reception of Darwin particularly in German journals see Engels 1995, 2000a, 2000b.

[28] See Chapter 2 by Paul White.

designer as necessary for understanding the 'origination of fresh species'. And, into the bargain, they had also left the tram-road of solid philosophy of science. Herschel, Whewell, Sedgwick and others based their criticism not on philosophy of science but on metaphysics. They were not consistent enough in pursuing their own methodology and standards. It was Whewell who had hinted at the 'impossibility of conceiving God's actions by assimilating them to our own' (1836, 361). The consequence for biology from this, however, would have been – already for methodological reasons – an agnosticism and not the insistence on the idea of an intelligent designer.

John Durant claims that Darwin's *Origin* is 'the last great work of Victorian natural theology' as well as 'the greatest (if not actually the first) work of Victorian evolutionary naturalism' (Durant 1985, 16). Our analysis, however, leads us to the conclusion that Darwin's *Origin* was no longer a work of Victorian natural theology but the Trojan horse by which evolutionary naturalism, which represented the victory of secondary causes over intelligent design, began its triumphal procession into the life sciences.