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Darwin's Book: *On the Origin of Species*

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Abstract This essay is an interpretation of Charles Darwin's *Origin of Species*. It focuses on the contents of the *Origin* as Darwin intended them to be understood and the background to the work, thus revealing the originality (or otherwise) of the work.

1 A Composition and a Commodity

When the *Origin* first appeared late in November, 1859, it was business as usual for one man: John Murray, the book's prominent London publisher on Albemarle Street. Its paper, ink, cloth and board could constitute a book because its composition, production, marketing and consumption made it that kind of commodity; and it could be the particular commodity it was because a highly reputable man of science had composed it

This essay is written against the background of a huge amount of work on Charles Darwin—his life, his science, his predecessors, his contemporaries and their culture, the successors and the fate of the ideas, and much more. Necessarily therefore much is presupposed in this essay. To start into this pertinent literature, begin with the *Origin* itself, the first edition (1859), easily available online or as an inexpensive bound book (the best is the facsimile edition, with an introduction by Ernst Mayr, published by Harvard University Press). The best way to make a start on interpretive issues is to go to the two *Cambridge Companions*: one on the *Origin* (Ruse and Richards 2008), and the other on Darwin (Hodge and Radick 2009). Documentation for much of what is said here about Darwin and his work can be found in two volumes: Hodge (2008a, b). The Dewey-Mayr thesis is discussed at greater length in Hodge and Radick (2009). Capitalist contexts are explored more fully in Hodge (2009). The zoologist David Reznick's (2009) book on the *Origin* now provides the most detailed guide to its fourteen chapters and to their connections with current evolutionary biology. To sample recent studies by many specialists writing on the reception of Darwin's ideas, see Engels and Glick (2009). The *Cambridge Encyclopedia of Darwin and Evolution*, edited by Michael Ruse, contains many pertinent essays and articles, including one by the author on the origins of the *Origin* in Darwin's early notebook theorising (Ruse 2012a). This encyclopedia and the two *Cambridge Companions* provide further guidance to the secondary literature. They direct one also to indispensable websites, most notably the *Darwin Online* website managed by John van Wyhe.

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appropriately for a particular literary genre: an authoritative, but also innovative and controversial, work of science commercially published (Kohler and Kohler 2009).

Murray and Darwin's collaboration, though unexceptional at the time, was made possible by recent technical and economic developments in the making and trading of books, developments responding and contributing to changes in peoples' employment, leisure and aspirations and so in society itself. Darwin had earlier followed Lyell—they were both Whigs—in publishing with the Murrays, a Tory Scottish family dynasty. Since 1845, in its less expensive Colonial and Home Library series, the firm had been doing well with the second edition of Darwin's *Journal of Researches*, his far more inviting and readable, and far less controversial, *Beagle* voyage book, priced at about a week's pay for a laboring man, and initially also purchasable in three, monthly parts billed as cheap literature for all social classes. At the wholesaling of the *Origin,* George Mudie bought for his national chain of commercial lending libraries 500 copies of the 1,250 printed, a transaction with no precedents half a century before. Materially very respectable but not luxurious, each volume retailed for around half the wages many men and most women earned in a month. Bound in were thirty two pages listing, with prices, several hundred Murray publications.

There was a mismatch between Murray and Mudie's aims and expectations and Darwin's hopes and fears. Darwin cared little for the lending library readers, much more for what the book would do for his standing and the acceptance of his views among his peers in British and foreign scientific elites. He even flattered his closest scientific friends—Lyell, Huxley and Hooker, in his eyes the nation's most eminent geologist, zoologist and botanist—by claiming to be content if they alone were initially won over to his theories, since their public support would eventually get decisive numbers of others to give him a hearing at home and abroad. The *Origin* descended indirectly from a textual ancestor, the essay of over two hundred manuscript pages that Darwin had salted away in 1844 in a fair copy to be published were he to die before completing a more extensive version of it; and this essay had been adapted even more closely to winning over a handful of special scientific associates (Darwin 1909).

What mattered much more to Murray and Mudie was what Darwin had had no part in initiating or directing to his own ends: a decade and a half of sensational sales and massive influence on discussion, in popular forums as well as elite circles, of a shorter and cheaper book than Darwin's *Origin*. It was a book first issued anonymously, by a leading London medical publishing house, that same year, 1844. Written by the Edinburgh publisher and journalist Robert Chambers, *Vestiges of the Natural History of Creation* was a book judged, not only by its few ardent supporters but also by many of its more numerous vehement opponents, to offer a very accessible, engaging account of lawful progressive development throughout nature and society, from nebulae condensing into stars in the heavens to men descending from apes here on earth. Predictably, the *Origin,* although written as a successor to Darwin's essay of 1844, was often read as a sequel to *Vestiges;* and any accounts of Darwin's book as at once composition and commodity must comprehend such complications (Secord 2000).

Historians of science are trained and paid to replace simple stories, so they cherish these complications. I am contributing to this issue of this journal as a historian of science specifically invited to write as one. In my concluding remarks I discuss why historians of science write as they do, and not as scientists and philosophers tend to. Historians of science are obviously expected to study many different aspects of any book as instructive and influential as the *Origin*. What come next in this essay are attempts to relate the book's content to its structure so that its composition can be related to its contexts.

2 The Descent of the *Origin*

There are complexities in the descent of the *Origin* from its textual antecedents. Between the essay of 1844 and the *Origin* came what Darwin called his big book, *Natural Selection* (Darwin 1975). This book was the vast projected treatise he started writing in 1856 and quit working on in summer 1858—never returning to the task—when Wallace's letter, with his handwritten essay enclosed, prompted Darwin to compose an abstract of the big book for speedy publication. The abstract was initially intended to be a few dozen pages long but quickly grew into the half-a-thousand that appeared in November 1859. The essay of 1844 had itself an antecedent, a sketch of three dozen manuscript pages roughed out in 1842; and this sketch had expounded theories and arguments first arrived at in notebook entries over the months from spring 1837 to summer 1839.

Lyell used to exasperate Darwin, not perhaps deliberately, by sometimes describing the *Origin* as expounding a revision of Jean-Baptiste Lamarck's views in his 1809 book: *Philosophie Zoologique*. What Lyell did not know was that this description was in a way correct, thanks to a sequence of influences that Lyell had himself been responsible for, albeit unwittingly. Before Darwin had ever read Lamarck's book, he had absorbed the fifteen-page synopsis of its teachings in Lyell's *Principles of Geology* (1830–1833; the synopsis appeared in the second volume published in 1832). This account of Lamarck's views influenced Darwin as Lamarck's own version could never have done, because Lyell's version was quite different in structure and content from Lamarck's. A fuller succession of antecedents of the 1844 essay and so of the *Origin* can be discerned once this complication is recognised: Lamarck's own version of his system appears in 1809; a radical transformation of it is expounded—and rejected—by Lyell in 1832; Darwin opens his *Notebook B* in July 1837 with two dozen pages sketching a system deliberately matching, in its structure and content, Lyell's version of Lamarck, but with consequential departures and additions; within days this system is transformed by Darwin into another, new version involving a new conception of the tree of life (Barrett et al. 1987); this new version is eventually changed decisively when the theory of natural selection is integrated with this conception of the tree of life, starting late in 1838 and early 1839, and so when the views later set out in 1842, 1844, 1856 and 1859 are first largely in place.

All such complications in conceptual and textual transformations are not only pertinent to biographical and bibliographical narratives; they can provide indispensable light on the argumentation of the *Origin.* The first edition's thirteen chapters, after the introduction and before the final recapitulating and concluding chapter (XIV), form three clusters: an opening four chapters (I-IV) making the case for natural selection as existing in the wild, and able to produce new species from old; next, five chapters (V-IX) addressing supplementary issues and countering difficulties, and then four more chapters (X-XIII) showing how many kinds of factual generalisations about species the theory of branching descent by natural selection can explain. Essential to what Darwin calls—in opening his closing chapter (XIV)—the one long argument of the book is, therefore, the dichotomous divide between those first four (I-IV) and later four (X-XIII) chapters.

This divide descends from a dichotomous divide in Lyell's synopsis of Lamarck, a divide with no precedent in Lamark's own exposition, but a divide matched in Darwin's systemic sketch of July 1837 (Barrett et al. 1987, 180, B: 1–24): a divide between a first section on adaptive branching species descents going on now, and a second section on escalating progress, from the simplest organisms to the highest, over eons of the past. In 1838, months before Darwin integrated his tree of life with natural selection, this divide had been transformed into a successor divide decisive for his plans for the prospective

book he already had in mind. This transformed divide is very much what will structure the *Origin*: a divide between making, first, the evidential case for a theory about the causes of species origins in branching descents, a case independent of any facts the theory is to explain, and then, second, making a further evidential case for the theory by demonstrating its explanatory virtue concerning many different kinds of facts. With this divide, and its precedents in Lyell's *Principles* and Newton's *Principia,* the argumentational exposition of the *Origin* is not back-to-front but the right way round according to traditional norms (contra Sober 2010). The rationale for this divide is best introduced after a brief look at the evidential ideals decisive for the whole book.

3 *Analogia, a Fortiori* and *Vera Causa*

Darwin's case for the adequacy, the competence of natural selection as a cause of species origins in branching adaptive descents invokes an analogy with the form of a traditional analogy as proportionality: the struggle for existence is to wild animals and plants as a human breeder is to domestic ones. With any analogical proportionality there is a relational comparison, here a comparison between two causes: the struggle and the breeder. For these two causes have the same relation to the animals and plants, wild and domestic respectively, that they act upon. It is a causal relation: namely, causing hereditarily variant individuals to differ in their chances of survival and reproduction. Although relationally alike, the struggle and the breeder are intrinsically, in themselves, very unlike agencies. The natural selection entailed by the struggle and the artificial selection entailed by the breeder's practises are alike both relationally and intrinsically. Darwin's reasonings to and from the selection analogy depend on these relational and intrinsic comparisons, and on intrinsic contrasts too: natural and artificial selection are the same kind of causal process, but differ in degree, nature's selection being vastly more powerful.

Arguments *a fortiori*, from the stronger, can deploy just such comparisons and contrasts. Consider the alternation of a proportion, as in inferring from ten being to five as two is to one that ten is to two as five is to one. Darwin argues not only to and from the proportionality between natural and artificial selection and their respective effects, he argues also to and from its alternation: natural is to artificial selection as wild species formations are to domestic variety formations. Given that nature's selection is so much more powerful than man's, and that man's selection can produce varieties on the farm, then, *a fortiori*, natural selection can produce far greater effects, species, in the wild.

The *vera causa* evidential ideal had no inherent connection with analogical nor with *a fortiori* reasoning; but this ideal is integrated in Darwin's *Origin* with both. A traditional requirement for a causal-explanatory hypothesis was that the cause it invokes should be shown to be able to produce the kinds and sizes of effect that it is to explain. Further, a good hypothesis should be able to explain many different facts about those effects. Such explanatory virtue is evidence for the existence of this cause and for its responsibility for those effects; but, because this evidence for the existence of the cause is not independent of the facts explained, the hypothesis and the cause are deemed conjectural, speculative, hypothetical. By contrast, a *vera causa* is a cause that has its existence also evidenced independently, by facts other than those it is to explain. So, to show that some causal-explanatory theory is no mere hypothesis but a *vera causa* theory, and hence inductive, not conjectural, three requirements had to be met: the two met by any good hypothesis—evidence of causal adequacy and demonstration of explanatory virtue—and a third, the

requirement that the cause be a real, true or known cause, a cause, that is, with its existence evidenced independently of the theory's explanatory virtue.

This *vera causa* requirement was defended canonically by the eighteenth-century Scottish philosopher Thomas Reid in elaborating on a Newtonian dictum. Darwin, following his early commitment to Lyell's geology, with its claim to be *vera causa* kosher endorsed by John Herschel (1830), had long seen the requirement as an ideal for all good theorising in inductive science. In conscious accord with this conviction, in the first four chapters of the *Origin* (I-IV) Darwin argues for the existence of natural selection, and for its ability to form new species from old in indefinitely extended branching and diversifying descents; while in those later four chapters (X-XIII) he makes the case for branching natural selection having been responsible for the formation of extant and extinct species. The case is made by displaying this theory's ability to explain many factual generalisations—geographical, embryological and other generalisations—about species.

Darwin has then addressed three questions about natural selection: Is it? Could it? Did it? His selection analogising relates to his three evidential cases—the existence, the adequacy and the responsibility case—in distinct ways. The analogy does not contribute to the existence case; for natural selection is shown to be an existing cause, a *vera causa*, through arguments from Lyellian geology, Malthusian population dynamics and generalisations about variation in domestic animals and plants, but not from generalisations about their selective breeding. The analogy does evidence the power and so the adequacy of natural selection; and because the analogy shows what effects natural selection can have, it shows what facts can be explained as its effects in making the responsibility case.

4 The First Four Chapters (I–IV)

Introducing the first (1859) edition of the *Origin* requires trawling through its chapters—after a warning and a suggestion: Darwin's prose is often not very lucid; for Darwinism expounded more clearly one goes to the books of Alfred Russel Wallace.

The opening chapter (I) on variation in domesticated species discusses variation itself, and then variation as accumulated through the art of selective breeding; the second chapter (II) concerns variation but not selection in nature; the third (III) introduces the struggle for existence in nature, and indicates briefly how it causes in wild species a natural selective breeding comparable intrinsically and relationally to man's selection; then the fourth chapter (IV), devoted to natural selection, argues that due to its powerful cause, the struggle for existence, natural selection is adequate, powerful enough, to produce over eons, from common ancestral species, unlimited adaptive, branching divergences and so unlimitedly diverse descendent species.

Throughout these chapters there are not merely appeals to factual generalisations about variation or selection on the farm or in the wild; for the arguments include premises about the causes of these tendencies and processes. One rationale for these causal emphases is that all four chapters contribute to an explicit contrast: the tendency to variation in domestic species is greater than the tendency to variation in the wild; but with the selective breedings it is the other way round: nature's selection so vastly exceeds in power man's as to more than compensate for the lesser tendency to variation in the wild. Variation on the farm and in the wild have the very same causes: changes in conditions—of soil, nutrition, weather and so on—that disrupt sexual and asexual reproductions which would in unchanging conditions yield offspring exactly like their parents. However, these causes of variation are active and effective to a higher degree under domestication than in nature. By

contrast, the causes of selection under domestication and in nature—the human breeder's practices and the struggle for life—are entirely unalike, but their selective consequences for survival and reproduction are the same in kind though not in degree.

The first causal theme in the opening chapter (I) is that in domestic species inherited variation is abundantly caused especially by influences on the parents, influences affecting the reproductive elements prior to conception, and also by the effects of habits or indeed by the direct action of changes in diet and the like; while the second causal theme is that selection by man, rather than crossing or inbreeding, has been by far the main means whereby this inherited variation has been accumulated over successive generations so as to make distinct varieties or breeds serving man's uses or fancies. Conspicuously there is no emphasis here on the inherited variation due to preconceptional influences arising by chance, by, that is, the action of small, hidden, unknown prenatal causes that produce useless and unwanted as well as useful and wanted variations; but the implication is that selection is efficacious in working with any inherited variations whether due to chance or not. This efficacy is evident in methodical selection when the breeder works deliberately to make a variety to fit particular needs or wishes; and even more in the unconscious selection resulting from the practice of breeding from the best individuals over many generations, with no conscious intention of changing the whole breed.

There is one principal causal theme in the second chapter (II), but it is not presented explicitly there, only in the recapitulation at the book's end: geology, Lyell's geology that is, shows that every region has been and still is continually undergoing physical changes, so animals and plants are at all times caused to vary heritably under nature just as they are in changing conditions under domestication. The second chapter itself argues that species in larger genera usually have more varieties than species in smaller genera, because there has been more variability in wider ranging groups exposed to more varied conditions. Here, Darwin interprets varieties as incipient species, and species as well-marked varieties differing in degree but not in kind from varieties. The third chapter (III) emphasises that there is always in the wild a competitive struggle to survive and reproduce owing to the tendency of all species to increase their numbers, and to the checks to those increases from limitations on food and other resources. The principal causal theme of the fourth chapter (IV), on natural selection, is anticipated here when this struggle is cited as the cause accumulating hereditary variation selectively and so adaptively.

The fourth chapter itself starts with the greater power of nature's over man's selection due to nature's being more prolonged, more precise and more comprehensive; nature selecting over eons among all those very slight variations making for small, but in the long run decisive, differences in chances of success or failure in the competition to survive and reproduce. Complementing this natural selection in competition for survival and reproduction, there is sexual selection in competition in winning mates through male combat or female choice, with arms (stags' antlers) or charms (peacocks' tails). In the middle five chapters, sexual selection will be integrated with generalisations about variation in secondary sexual characters; and will be enhancing the causal adequacy of selection generally, especially in causing features too disadvantageous in the struggle for life to be due to natural selection. However, in the later cluster of four chapters (X-XIII), Darwin will find no explanatory work for sexual selection. This complement to the theory of natural selection, as it is in the *Origin*, has to wait until 1871 and the *Descent of Man* to come fully and publicly into its own as an explanatory resource.

The end of the chapter (IV) is dominated by the principle of divergence: structural and functional specialisation is usually advantageous in life's struggle; so over eons natural selection causes, reliably if not invariably, structural and functional divergences by tending

to favor diverse adaptive specialisations; so causing diversifying, branching descents among the more specialised winning species and terminal extinctions among the less specialised losers. Since increased structural and functional differentiation in animal and plant organisation constitutes progress, natural selection as a reliable cause of adaptive change is no less a reliable, if not invariable, cause of progressive change.

5 Three General Evidential Considerations

Writing on the 22nd of May 1863 to George Bentham, the eminent botanist and author when young of a book on logic, Darwin insisted that:

> the belief in natural selection must at present be grounded entirely on general considerations.(1) on its being a vera causa, from the struggle for existence; & the certain geological fact that species do somehow change (2) from the analogy of change under domestication by man's selection. (3) & chiefly from this view connecting under an intelligible point of view a host of facts.—(Letter to George Bentham, 22 May 1863, Darwin 1985, 11:433)

By contrast, he says, with these general considerations, when we descend to details we can confirm of no one species that it has changed, nor that the supposed changes are beneficial, nor why some species have changed while others have not. This contrast between the general and the particular evidences may seem to concede more than Darwin does in the argument of the *Origin*, which is after all full of details about particular species in the wild and varieties in gardens, on farms and in pigeon lofts. However, the book's argument always works within this concession, in that all such details are in support of general grounds for accepting the theoretical theses, rather than providing direct testimony as observed instances of branching descent or of natural selection in action.

In Darwin's three general considerations, the invocation of geology in the first one is cryptic. Once again, what Darwin needed to say here is that geology shows that wild species live in continually changing conditions causing inherited variation. It is this causation, together with the struggle for life, which, he holds, entails the existence of natural selection in the wild. The second general consideration is the analogical comparing and contrasting of nature's selection with man's in establishing what nature's selection can do in its much longer run. So much then for the *Origin's* first four chapters. The third general consideration refers to what is expounded in the later four chapters on geology, geography, morphology and the rest.

In enlightening Bentham, Darwin does not cite the selection analogy as establishing that natural selection is a *vera causa,* an existing cause; and quite rightly (Ruse 1975 is mistaken in this). In his notebooks when first arriving at his theory of natural selection and in the *Origin*, Darwin does not do what it is easy but mistaken to assume he must have done: namely, to argue that domestic varieties are known to be produced by man's selection on the farm, that species are like domestic varieties, so, therefore there exists in the wild a similar natural process of selection which produces species. Rather, in the notebooks and in 1859, the argument for the existence of selection in nature appeals to the existence in the wild of inherited variation, and to the existence of a struggle for life acting discriminatingly on that variation; so there exists a process of cumulative discrimination of variation in nature; and this process is like selective breeding on the farm but much more powerful. What is known about man's selection and about its relational and intrinsic likeness to natural selection does not establish that natural selection is an existing cause, a *vera causa;* but it does indicate, as in Darwin's second general consideration, what this natural process can produce.

6 On the Middle Five Chapters (V–IX)

Darwin's three general evidential considerations do not map onto the *Origin's* three clusters of chapters. The first of the middle five chapters (V), on laws of variation, supplements the book's two opening chapters (I, II) on variation under domestication and in nature. The middle three of the middle five (VI-VIII) then counter objections to the thesis of the book's fourth chapter: that natural selection is competent, adequate to cause the formation and adaptive diversification of species. The last of the middle five (IX) belongs with the later four chapters, the chapters displaying the theory's explanatory virtue, and so providing the evidence for natural selection having been responsible for producing the extant species living today and the extinct species commemorated as fossils. For, this fifth chapter of the middle five takes care in advance of an objection to that responsibility case; and does so by insisting that the fossil record is not a complete and reliable record of sporadic, sudden, jumpy exchanges of new species for old; rather, it is a patchy, gappy, intermittent, damaged, fragmentary record of what were gradual transitional changes in species and in their conditions of life. So, properly understood, the fossil record presents no insuperable difficulties for the view that those changes were slowly, smoothly wrought in gradual branching descents by means of natural selection.

Opening that middle miscellany of five chapters, the chapter on laws of variation (V) begins with Darwin saying that he has sometimes spoken of variations being due to chance, but that this expression is improper in implying that all variations are not due to lawful causes. In fact he has talked only once or twice in passing of chance variations, and the larger aim of the chapter is not limited to correcting any misleading impressions such talk might have given. For what the chapter mainly argues for is a unification thesis. Variations in domestic and wild plants and animals all conform to the same laws. For instance, organs developed to an extreme degree in some organisms will be very variable in their more normal close relations. Again, the laws of variation are the same for species as for varieties; structures varying between species vary similarly within species. So, this chapter contributes to the thesis, of the book's second chapter on variation in nature (II), that species and varieties differ in degree but not in kind, species being well-marked varieties and varieties incipient species.

After this chapter on the laws of variation comes a chapter (VI) often anticipating and countering various reasons for thinking natural selection incapable of producing new species from old, because some species have features that selection can not produce, especially such organs of extreme complexity and perfection as the eye. Darwin's countering of this difficulty appeals to the existence today of a graduated array of useful organs from the eye on down to simple structures conferring mere sensitivity to light, an array that makes it conceivable how eyes could be produced gradually over eons by natural selection. The following chapter (VII) takes on equivalent challenges presented by complexity and perfection in instincts such as honey bees exhibit in building their combs; and the same countering strategy is deployed here. In explaining how sterile neuter insects could owe their instincts to natural selection when they do not breed over successive generations, Darwin argues that if selection is admitted to take place among families as well as among individuals the difficulty can be overcome. He implies that this admission entails no significant amendment to the theory of natural selection, as farmers have likewise improved the quality of castrated steers by consistently breeding from the parents of the best.

The next chapter (VIII) confronts the objections that species are quite unlike varieties in their inability when crossed to produce fertile hybrid offspring; and that this intersterility of

species permanently ensures the distinctness of species, and is not a feature of species that natural selection could produce. Darwin disputes the view that all and only species and no varieties are intersterile; for intersterility is not always either completely present or completely absent in species or in varieties but comes in degrees; and he argues that, while not directly due to the action of natural selection it can be indirectly so, because it is a gradual, incidental consequence of those adaptive divergences in hereditary constitutions produced by natural selection over many generations. Here too, then, no amendment is needed to the theory expounded in the book's first four chapters.

7 On Those Later Four Chapters Preceding the Last One (X–XIII)

These later four chapters take up three clusters of topics; for the first (X) is on geology—which, recall, has just had the last of the middle five devoted to it—the next two (XI, XII) to biogeography and the fourth (XIII) to taxonomy and morphology including comparative embryology. These three clusters may seem distinct enough that no unifying themes can be seen running through them all, except the theme itself of branching descent by means of natural selection or branching selection for short. However there are revealing, recurrent themes in Darwin's many deployments of branching selection as an explanatory resource. It is worth dwelling on these themes as Darwin gives no clue as to why he has treated these three clusters of topics in the order he adopts. Nor does he explain why he gives the third cluster far fewer pages than the second, biogeographical cluster, an imbalance without a precedent in the *Essay* of 1844. One is tempted to guess that doing so allowed him to finish a text that had already taken many more months and more words than originally planned.

Consider next an exegetical mistake about the book as a whole (Sober 2010). That mistake would view its early chapters as concerned with natural selection, and these later ones as concerned instead with common descent. That this view is mistaken can be confirmed simply by noticing Darwin's repeated references to natural selection throughout these four later chapters. Now, although mistaken, this view can be useful for three reasons. First, Darwin is often appealing to common descent without appealing even implicitly to natural selection. For instance he discusses the geological generalisation known as the law of the succession of types, the law that the extant species found as fossils in any region are often similar enough to the extant species living there as to belong in the same genera or families. Naturally, Darwin explains this close likeness as due to descent, and declares descent supported evidentially by its yielding this explanation; but he does so without explicitly complementing this declaration by urging that the slight differences between the extant and extinct species are best explained as due to selection. What such cases indicate, then, is that Darwin in these chapters does far more explaining of resemblances as caused by descent than explaining of differences as caused by selection.

A second reason for that exegetical mistake being useful concerns alternative explanatory options. Consider various traditional explanations for structural and functional resemblances among animals and plants (Russell 1916). Some resemblances might be explained as due to the organisms being near each other in a scale of organisational perfection, the assumption being that only one type of organisation is possible at any one level in this scale. Other resemblances might be explained as due to common fittings, adaptations, providential or otherwise, to common ways of life, aquatic life, say. Again, both these explanations—common level and common adaptation explanations—might be rejected and an explanation given instead by showing that these organisms, the vertebrate animals for example, are all constructed on a common plan (as is argued by Owen 1849).

By Darwin's time common level explanations, and the assumptions they made, were no longer widely favored, although they are prominent in *Vestiges*. By contrast common adaptation and common plan explanations both had their supporters. Darwin often sided with the common plan supporters in agreeing that in many cases, the vertebrate animals especially, there was no common way of life so no credible crediting of common structure to common adaptation. However, he denied that referring such resemblances to a common plan was genuinely explanatory rather than merely descriptive. By contrast, he argued, common descent is a *vera causa*, a cause known to exist, and is a cause known to produce structural and functional resemblances, among human or among animal cousins, or indeed among the varieties of man, or among the varieties of any other one species, when that species is taken to trace a single original stock.

Third, explaining resemblances as due to shared descents is a theme running all through Darwin's chapters on geology, biogeography, classification and morphology; but, again, what of the divergences causing the differences among the commonly descended ? These divergences Darwin almost always explains as adaptive divergences, presumptively owing therefore to adaptive, diversifying selection. This explanatory practise looks, then, like an inevitable complement and partner to explaining unadaptive resemblances as due to common descents. There is a complication however. In defending common descent explanations, Darwin is prepared to discount the other usual options: common adaptations and common plans; but he seems less inclined to do the equivalent discounting of other options in displaying the explanatory virtues of natural selection. Indeed it is hard to see how he could have done so. For what does he need to conjoin with his common descent explanations? Surely, any causes of gradual, adaptive divergences would allow him to explain the adaptive differences, while crediting the nonadaptive resemblances to common descent. So, it would be difficult to defend natural selection as the only or even the best explanation, the most likely cause, in all or most instances. For, to take the most familiar alternative, divergences among the varieties within any one species were often explained by many naturalists as resulting from the inheritance of acquired characters working gradually and adaptively over many generations.

Strikingly Darwin never confronts this issue about such other options in a direct, sustained way, not even when he might have supposed it most appropriate to do so. Consider his account of the Galapagos land birds as exemplary for his enlisting of biogeographical generalisations in supporting common descent. Many species that have originated on these arid islands resemble closely species living on the rainy nearest mainland, rather than resembling species original to other arid volcanic oceanic islands around the world. Explained as resulting from ancestry, these facts are readily reckoned as support for descent; but with no complementary explaining of the differences as due to adaptive divergences caused by natural selection. Again, consider Darwin's treatment of the tendency of vertebrate embryos to be more similar than the adults. The resemblances themselves, among the embryos as among the adults, he ascribes to shared ancestry. The tendency of the embryonic resemblances to be closer he ascribes to natural selection, arguing that adults live in more diverse circumstances than embryos, and will have diverged more in being adapted by natural selection to those more diverse circumstances. But, again, he does not clarify why this cause of gradual adaptive divergence should get the credit for this explanatory success rather than any other gradual, diversifying, adaptive causal process, such as the inheritance of acquired characters, a causal process Darwin has not rejected anywhere in his book, and which he knew was accepted by almost all his readers when explaining intraspecific adaptive diversification.

8 Understanding the Divide

This task of understanding the relations between the opening four chapters and these later four involves difficult issues of interpretation; and they are not issues clarified in Darwin's closing chapter. As the reader might expect that chapter offers no additions or alterations to the theory of branching descent by means of natural selection. There is a full recapitulation of all the objections to the theory, and of the counterings to them offered throughout the book; then come pages discussing the reasons why most scientists have not previously embraced species origins in gradual descents, and why they are likely to resist his proposals; finally, the closing pages give an overview of the interesting avenues for further inquiry, and of the enhanced appreciation and comprehension of nature's ways, that would come with a widespread adoption of the book's teachings.

So, this interpretative task can only be met by reflecting on those two clusters of four chapters themselves. Consider next an obvious asymmetry and priority. The opening chapters provide the explanatory resources and the later ones bring those resources to bear on the explanatory challenges. Insofar as comparative morphology, including embryology, is nowhere sustainedly engaged in the whole book until its thirteenth chapter, themes and theses that are not embryological are taking precedence, therefore, and are taken to be more fundamental than embryological themes and theses about individual development, ontogenetic themes and theses in later jargon. This secondary position for ontogeny obviously marks a sharp contrast with any theory of progressive development, such as *Vestiges* presented, where longer run changes over eons, phylogenies, are explained as extrapolations of individual developments, ontogenies.

This contrast can highlight a leading feature of the *Origin's* theorising. For in this book the main extrapolation is another one entirely; it is the extrapolation from intraspecific, adaptive intervarietal divergences, to interspecific adaptive divergences, where intraspecific adaptive divergence includes divergent fittings of domestic races to different human wants and uses. Now, such adaptive diversifying in domestic species had long been seen by ethnologists—especially those, such as James Prichard (1813), later labelled as monogenists (for their belief in a single original human stock)—as providing explanatory resources in understanding the causes for human varietal diversity; and, more generally, the causes for any intraspecific diversity, as in Lyell's account of all species in his integrating of geological, geographical and what would later be called ecological generalisations about the lives and deaths of all species.

Darwin's extrapolationary theorising is not then from ontogeny to phylogeny as ontogeny writ large, but from intraspecific adaptive divergence—as ethnologically, geologically, geographically and ecologically interpreted—to interspecific adaptive diversification. Note, however, that individual ontogenies do have places in his opening chapters; two places most conspicuously. First, variations may often have preconceptional causes but, Darwin insists, as in variations in cows' horns, the variations do not show themselves until adulthood is nearly reached; and when transmitted from parent to offspring they usually appear at that same stage in the offspring's life. So, as Darwin emphasises in the late chapter on embryology, these two tendencies in variation are causes contributing, along with selection of these variations, to making adults less similar than embryos. Second, Darwin's account of his principle of divergence draws on ontogenetic generalisations owing to von Baer (1853), most obviously the generalisation that ontogeny involves structural and functional differentiation; for Darwin argues that the advantages of adaptive specialisation ensure that phylogeny likewise involves increasing differentiation

within the bodies of individuals, and between the many species descending from a single, common ancestral species.

This conclusion allows Darwin, in his fourth chapter, to find the causes of progress, if progress is identified with increased differentiation, in the cause, natural selection, of adaptive divergence. Von Baer had insisted on distinguishing between the level of organisation and the type of organisation; and Darwin's account of progress in branching descents conforms to that distinction. For Darwin implies that all the descendents of a single ancestral species may be higher in organisation than that ancestral species was, in being structurally and functionally more differentiated in their tissues and organs; but, while these descendent species may all be similar in organisational level, they may have different differentiations adapting them to different specialised ways of life in diverse conditions and circumstances.

Branching descent is then consistent with a reliable if not invariable tendency to progress in all or most divergent lines. However, Darwin's view that ontogenies recapitulate phylogenies had no sanction in von Baer. In chapter thirteen of the *Origin,* the ontogeny of each of the diverse descendent species recapitulates the distinct changes leading to that particular species from the common ancestral species, so different changes are recapitulated in different lines of descent. These recapitulations allow inferences back from present ontogenies to phylogenies in the past. But there is no predetermining of future phylogeny as an extrapolation of present ontogeny, no such predetermining, therefore, as is central to *Vestiges*. What determines the future changes leading on from any species today is not its past phylogeny, as recapitulated in ontogeny, but whatever future adaptive changes will be wrought by natural selection favoring different specialisations in different circumstances and conditions, and so in different lines of descent.

A very large and general issue is in play here. In many fields of inquiry in Darwin's day, as before and since, theorists saw themselves as having to adjudicate between historical, functional and structural considerations. Those theorists who strongly privileged structure and laws of structures, including laws about the development and transformation of structures, tended to discount historical and functional analyses as explanatorily unenlightening. Darwin's *Origin* does the opposite. For Darwin, history, that is ancestry, heredity and descent, and function, that is adaptive innovation and specialisation, together take explanatory priority over structural considerations. For Darwin, then, structuralist appeals to transcendent and archetypal unities, and to laws of form and development, provide explanatory challenges that are to be met with generalisations about ancestries and adaptations; indeed ultimately with generalisations about adaptations alone, in that any ancestral source of any structural unity has itself first originated as an earlier innovative adaptive divergence.

So, the divide between the early four chapters (I-IV) and those four later ones (X-XIII) is indeed a divide between what provides and what requires explanation, between what has explanatory priority and what does not. Darwin's one long argument running throughout his book has various integrative themes, some more easily followed in their unfolding and implications than others. One such implication is that strong structuralists have rarely felt satisfied, and not just with the thirteenth chapter, but with the book as a whole.

9 Innovation and Conservation

Historians are trained and paid to be sceptical about hyperbolic declarations that some famous book contained a totally new way of thinking that changed everything instantly for

everyone. They are also inclined to be pluralists, and so sceptical of claims that some famous author was driven in his or her whole life and work by some one vision, ambition or allegiance. Given what has been said about Darwin and his book, especially at centennial celebrations—see for example Seward (1909), Tax (1960a, b), Tax and Callender (1960), and Bendall (1983)—it can be salutary to bring these sceptical attitudes to a historian's account of the *Origin*.

The book's two big ideas, the tree of life and natural selection, were both radically novel and together constituted a fundamental and disturbing challenge to most readers within and beyond the scientific community. Darwin himself in his final chapter recognised how deep and disconcerting this challenge was; and no reviewers disagreed with him. Scepticism remains however a defensible stance in prompting reflections on what the book did not challenge.

Start with the heavens and the solar system. Here, in striking contrast with Chambers in *Vestiges* in the 1840s and Spencer (1868) in his essays in the 1850s, Darwin never invokes nebular theories—of condensations into solid globes of whirling clouds of fine matter—either for stellar suns in general or for our sun and its planets in particular. Nor does he discuss how the earth may have first formed, nor how its earliest life arose. There were precedents for not taking up these topics, precedents in the writings of two authors who were consciously allied on such issues, and whose authority Darwin took very seriously: Herschel (John, not to be confused with his nebular father William) and Lyell. Darwin followed these mentors in implicitly assuming the solar system to be stable, and so manifesting no signs of its beginning or end, and likewise with the stable balance of tireless causes destroying old habitable land and making new on the surface of the earth.

Darwin's view was that the earth's life has not merely changed but also progressed (Ospovat 1981); but this progressive play has taken place in a sidereal theatre and on a planetary stage subject to constant but not progressive changes. Moreover, this progressive play takes as given life as naturalists knew it, with its powers of heredity, variation and superfecundity, so that branching descent by means of natural selection is an explanation of how species owe their origins to these powers, but an explanation giving no account of how those powers themselves originated.

As for Lyell's controversial teaching, of the stable balanced system of aqueous levelling and igneous unlevelling agencies at work on the earth's surface (Rudwick 1969), Darwin takes this teaching over too, not just most explicitly in his two chapters on geology (IX, X), but throughout the book. The two chapters on biogeography (XI, XII) accordingly accept the transformation that Lyell had worked in that science by bringing his, Lyell's, novel geological theses to bear on explanations of how plants and animals are distributed geographically; the central innovation being to have extant species, like all species, originating not in sporadic batches, but continually, one at a time, over a vast period right up to the present, during which period those aqueous and igneous agencies have constantly formed and destroyed avenues (such as landbridges) and barriers (such as mountain ranges) to plant and animal migrations. On species origins themselves, Darwin broke not just with Lyell's commitment to independent, special creations of fixed species, but also with his commitment to the providential determination of the timing and placing of those events by adaptive considerations alone. However, in replacing those Lyellian commitments about species origins, Darwin accommodated his own innovations, the tree of life and natural selection, to Lyell's novel geology and its novel integration with plant and animal geography.

10 Species: Explaining and Explaining Away

On species themselves, it is natural to presume that the long argument of the *Origin* required a radically new conception of what species are. After all, many botanists, zoologists and geologists agreed that varieties and species are quite different kinds of entities; and that a main difference is that species have independent origins as so many distinct original stocks, never varying enough thereafter to give rise to new species either suddenly or gradually, while varieties branch off from one another, and so are neither separate in their origins nor fixed in their characters. Darwin's *Origin* continually confronts and replaces this whole line of thinking about what different entities species and varieties are, most directly when he argues that there is a continuum between species that are good species, exemplary instances of the term and never likely to be adjudged varieties, and less good, incipient species that might well be ranked as well-marked varieties, and again between these well-marked varieties and other lesser varieties, a continuum due to the gradualness of the adaptive diversifications wrought by natural selection.

However, Darwin's confrontations and replacements are accompanied with retentions of much contemporary thinking about what species were. Nor should these retentions surprise his readers, for two reasons. First, if Darwin had given the question about what a species is a drastically novel answer, his readers could have resisted his account of species origins on the ground that he may have disclosed the origins of species as he understood that term, but not as the term was normally understood; so that he had not tackled much less solved the problem of the origin of species in accord with any of the term's standard meanings. Darwin's solution to his problem would then be ignorable as no solution at all to what most naturalists' understood the problem to be.

Second, a historian might think that the standard views on species, and how species were unlike varieties, allowed naturalists to know a priori that new species could not have originated in gradual changes of older ones; just as theologians could know a priori that God, being completely perfect, could never change, since any change entails gains or losses in perfection. For, if species are essentially, by definition, and by criterial demarcation, independent in origin and fixed in character, then any account of their origins in gradual changes could be thought so inadmissible in principle that it would be a mistake to take such a proposal to be assessable through weighings of factual evidence. Indeed any historian who thinks that all innovative science does not simply bring shifts in beliefs, but also more fundamental shifts in meanings, might well assume that Darwin's arguments must have been rejected in this way. But the book was not met with such responses; and moreover Darwin was confident that it would not be, and so he did not anticipate and counter such responses in writing it. The main reason for this confidence was that for several decades, leading authorities, such as Lyell, and following him William Whewell (1837, 1840) and others, had taken the possibility of species origins in gradual transmutations not as an issue to be decided a priori, but as a fundamental factual issue to be decided by weighing the direct and indirect factual evidence.

What Lyell and other authorities had insisted upon was that the admission of gradual species transmutations would entail a nominalist rather than realist stance about species themselves. For the distinguishing of one species from another would be arbitrarily settled by naturalists' naming decisions rather than by nature's real distinctions; and that any general doctrine, as to what plant or animal forms are to be ranked and named as species rather than mere varieties, would likewise be conventional not natural. In the *Origin*, if not everywhere else in his writings, Darwin accepted that gradual transmutations entailed this nominalism about species. His acceptance of this entailment required him to clarify what it

was about species that he was explaining away as misleading appearance or mistaken inference; and what he was explaining as neither misleading nor mistaken. From the observed constancy of species over the years many naturalists inferred their permanent fixity and so independent origins. Darwin's view is that the observed greater constancy of good species as contrasted with minor varieties is to be explained by natural selection, not explained away; while the inferred permanent fixity and its corollary of independent origin is explained away.

In holding this view of good species, Darwin took into account the disagreements among naturalists over what diagnostic criteria should be used in reckoning a form specific and not merely varietal. For some appealed to kinds and degrees of difference in characters, or to lacks of character intermediates or to constancy of character differences, others to interbreeding aversions or to intersterility. In the *Origin*, Darwin was arguing for an explanatory shift not for taxonomic reform. He did not need to adjudicate among these diagnostic criterial options. He aimed to bring naturalists over to natural selection regardless of which options they favored; and to do so by arguing that natural selection produces from a single ancestral species diverse descendent species that meet all the diagnostic criteria that anyone, or at least any accredited practioner, had ever proposed, species that were good species by any reputable tests.

To that extent Darwin was far from dismissing or ignoring these diagnostic criteria, but was taking them all, insofar as they were consistent with gradual transmutations, as determining his explanatory challenge. Moreover, his view was that good species, as natural selection produces them, are constant and distinct enough in their characters to make naming them and giving them definitional characterisations reasonable and achievable objectives, so that the standard taxonomic practises of naturalists, including his own in his work on the barnacles (Darwin 1851a, b, 1854a, b), are not discredited but vindicated.

Similarly with classification generally: in his thirteenth chapter, Darwin did not say that common descent and natural selection made worthless all existing classificatory work. Rather, his argument was that so-called natural groupings and divisions of species, those that place the whales with mammals and not fishes, are vindicated as reflecting real ancestral, genealogical relations in nature, rather than representing only conventional decisions by naturalists. Conventional decisions come in the ranking of some real, natural group, some real branch in the genealogy, as a class rather than an order, say. As in the taxonomy of species and varieties, so in the taxonomy of wider groupings and dividings: the real causal process of adaptive diversification and its real production of a real tree of life, with real branchings and divergings, are explaining, and not explaining away, the real resemblances and differences used in arriving at those groupings and divisions, most obviously by explaining closer resemblances as due to more recent common descents and less close resemblances to more remote ones, and wider and narrower differences to more or less prolonged adaptive divergences.

11 Alignments

Even a glance at what the *Origin* rejected and what it retained of earlier theories and practices shows that the book was not an attempt to replace all that went before. It is likewise with what came after the *Origin*: there was no sudden, total changing to Darwinian thinking in all affected fields. Any crude story of a quick, wholesale shift from one hegemonic regime to another, in a Darwinian revolution, is then hopelessly unsustainable.

To be convinced that there was no consensus before the *Origin* and none afterwards either, one only needs to read, say, Adam Sedgwick's (1850), Baden Powell's (1855) and Louis Agassiz's (1859) books in the 1850s before the *Origin,* and Alfred Wallace's (1889), Yves Delages' (1903) and William Bateson's (1894) books four decades on.

That Darwin was not confronting and replacing a single hegemonic *ancien regime* entails that there are complexities in discerning who and what he was siding with and against. Note first, however, an issue the *Origin* takes no side on. Philosophers, theologians and savants often disagreed in the eighteenth century about nature, the natural world as whole: is it soulessly mechanical or animatedly organismic, more like a clock or a cabbage? Darwin's book does not address this question even implicitly. Certainly he writes of plants and animals as if they are machines, but for nature as a whole he comes out for neither clock nor cabbage. His leading analogies do not reduce his thinking about nature to a single interpretation: the natural world is sometimes likened to a farm or garden as a site for selective breeding; at other times, as in the geographical chapters, the British colonies, and empires generally, are invoked in talk of territorial and populational conquests of winning invading species over indigenous losers.

Again, when alluding to the relations between God and nature, he wrote as the theist—the deistical theist, a believer in God but not the Bible—that he still was, and not as a pantheist identifying God and nature, which he never had been; but he does not assume that nature's single authorship required the *Origin's* author to have a consistent, comprehensive, unified take on the nature of the natural world, beyond the usual contrast between the lawfulness of natural, secondary causes, and so of the ordinary course of nature, and the unlawfulness of any miraculous, divine, supernatural interventions made by God who, as primary cause, is the author of nature's laws, interventions the *Origin* does not admit, at least not after the earth's first life began. The drift, often implicit, of the *Origin's* theological themes, seemingly sincerely held by Darwin himself, is that, as the author of the laws, God is so far above nature and above man, that he has no direct causal or moral responsibility for life's details; and so can receive no credit for particular perfections and flourishings, nor blame for particular flaws and sufferings; there is, however, enough finite goodness consequent on life's long, overall progress that the pain and waste entailed by its production by natural selection do not constitute novel, insuperable challenges to traditional theodicies, traditional reconcilings of nature's evils with God's infinite goodness. So, Darwin himself did not think that what was new in his book required him to take an entirely unprecedented view of the relations between God and nature.

Darwin lived and wrote in a Europe that increasingly construed alignments on many issues as nationally distinguished. But again it proves hard to type the *Origin*, much less Darwin's whole life and work, as entirely and exclusively aligned with, say, the Scottish Enlightenment rather than with German Romantic counterings of the French Enlightenment (Richards 2002). The mentor the book owes most to is Lyell who was indeed aligned with the late Scottish Enlightenment with its strongholds in the liberal, Whig *Edinburgh Review,* in the Scottish universities and in the London University (founded and headed by Scots associated with that review and later called University College), and with its hostility to the alliance of the Tory party, the Church of England, and this established church's two staff colleges, the universities at Oxford and Cambridge. But, apart from Lyell (a consciously-dissident contributor to the Tory *Quarterly Review,* a Murray publication, and to the Anglican King's College, London) other mentors, such as the Englishman Malthus (1826) and Prussian Humboldt (1907), although heroes to enlightened Scots, can hardly be claimed for that alignment itself.

Consider just one measure of the lack in pre-Darwinian science of any single hegomonic regime: the failure of the preeminently powerful Georges Cuvier to get all his Parisian colleagues on his side (Coleman 1964; Appel 1987). Within the French national museum of natural history that Cuvier directed, Humboldt, in residence in that institution for many years, was generally far from deferential, while Cuvier's comparative anatomy was comprehensively opposed, in different ways, by Lamarck and Geoffroy St Hilaire; and his geology was no less comprehensively opposed elsewhere in the city by Constant Prévost. Lyell sided with his friend Prévost but not with Lamarck or Geoffroy. In siding with those last two Darwin was following Robert Grant, his Scottish Edinburgh mentor in invertebrate zoology, and an admirer, as he knew, of his own English grandfather, Erasmus Darwin; and, although disagreeing with Lyell in this alignment with Grant, he was following his Scottish geological mentor's example in siding with French opposition to Cuvier rather than with Cuvier's English followers at Oxford and Cambridge. There are comparable complexities in all the other many alignments and oppositions pertinent to any placing of Darwin and the *Origin* contextually; but this glance at this sampling surely suffices to discredit any simple choice between typing him and his book as either Germanic and romantic or English and unromantic. It will discredit too any notion that the *Origin*'s author was not an intellectual leading an *engagé* life of the mind, but a writer in the parson naturalist tradition doing ideologically innocent science grounded in the bodily practices essential to naturalists' practical skills in investigating nature. Darwin's book does owe much to those skills, but it also owes much to other bodily practices, especially the theorising he did with his brain.

The reader who welcomed the *Origin* with fewer and lesser reservations than anyone else was probably Wallace (1870, 1905). Darwin and he saw themselves as having independently arrived at very much the same theory of species origins in branching descents by means of natural selection, despite the instructive differences other commentators would later discern in their two versions of that theory. There are manifest, manifold contrasts between the two men in age, personality, family, class, education, politics and so in much else besides (Browne 1995, 2002; Shermer 2002; Fichman 2004). There is, to take just two examples from many, no match in Wallace's life for the Edinburgh medical studies Darwin shared with his brother, father and grandfather; again, Wallace's main lifelong oppositional passion was directed at domestic rentier land ownership, while Darwin's was directed at international slavery (Desmond and Moore 2009). Their common philosophical convictions included materialism (and perhaps too determinism) about mind and brain. Within science, if one asks what they and they alone had in common, which they had independently converged upon before they had natural selection in common, and which might then explain why they alone later converged on that theory, an indispensable if not complete answer has four parts: their comprehensive embracing of Lyell's geology—very few geologists, zoologists or botanists did this—with its novel biogeography; their integrating of Lyell's account of species extinctions with Malthus on superfecundity; their rejecting of Lyell's view that adaptation alone had determined the law regulating the timing and placing of species origins; and their deciding that common ancestries and adaptive irregularly branching descents would be the best replacement for Lyell's view on the determination of this law.

What comparisons and contrasts between Darwin and Wallace can do for any understanding of the *Origin,* is to show that the book was not presenting an obvious next step in the advancement of public biological science; and, equally, that it was not presenting a purely personal expression of one man's desire for truth. These confirmations of these commonplaces about what scientists write can alert historians to the fallacies inherent in

celebrating science in general as an inevitable march of progress, or in celebrating individual scientific heroes as transcending the contingent circumstances of their life and work.

12 The Long Run: The *Origin* and Platonism

If the *Origin's* relations with what came shortly before defy simple summaries, perhaps the quest for simplicity has to be displaced to the longer run of history. Can it not be said that the book was the final replacement for the old religious stories of the earth, life and man's creation, or the final replacement for the ancient Greek metaphysical prejudices privileging permanence and plan over change and chance? Was not this the book that replaced all these legacies with modern science? (Mayr 1982)

To raise doubts about all such narratives, it suffices to question the thesis John Dewey contributed to the 1909 centennial, the thesis broadly revived, seemingly unwittingly, by Ernst Mayr for the 1959 celebrations; it is the thesis that Darwin was overthrowing the long domination of Western thought by Plato and his pupil Aristotle's doctrine that species as forms are not just fixed sources of order in nature, but origins so fixed and so original that they can have no origins (Dewey 1910). The historiographical appeal of this thesis is undeniable. For Darwin, nature is not ordered by forms but by laws, and so species can have origins within the lawful order of nature. Here, then, is a deep and revealing contrast with Plato and Aristotle. Moreover, in Darwin's day Plato and Aristotle's teachings were alive and well among zoologists and botanists as well as philosophers and theologians. Agassiz's scientific rejection of Darwin was reinforced by his metaphysical preference for Plato. The most powerful men at Oxford and at Cambridge, Benjamin Jowett and William Whewell, were both admiring republishers of Plato's dialogues; and Whewell explicitly saw Darwin's theory as a new but quite unacceptable version of the ancient Democritean atomist teaching rejected by Plato. (This comment occurs in a new preface to the 1864 edition of Whewell's *Bridgewater Treatise*, first published in 1833). A leading literary figure was said to have said of the *Origin's* teaching that it was all in the poem of Lucretius, the Roman follower of Democritus and Epicurus.

Dewey and Mayr conspicuously agreed in ignoring the Greek alternatives to Plato and Aristotle developed by the Epicurean and Stoic traditions. Epicureans and Stoics differed from each other about all the fundamental cosmological issues. They did agree, however, in not developing any theory of forms as origins of natural order. Both schools likened that order to a lawful social order, but neither had a comprehensive account of a single, unified constitution of laws ordering the whole cosmos as a constitution of laws orders a whole state.

The medieval philosophical defenders of the three Abrahamic monotheistic religions, Judaism, Christianity and Islam, disagreed on much, but were united in preferring Plato and his God to Democritus and his fortuitous concourse of atoms. In the thirteenth century, Thomas Aquinas made no concessions to Democritus in integrating Platonic accounts of species, as Divine Ideas in the mind of God, with Aristotelian accounts of species as the enmattered forms of bodily creatures. His understanding of the ordering of nature also integrated species as forms with laws, as many laws as there are forms of distinct specific natures in the whole scale of natures from the lowest creatures to the highest, the angels; so that for each species there is a law of its nature; a law for tigers in their being and becoming, and their increasing and multiplying, in accord with divine commands issued a few thousand years ago in the world's first week; and another law for lions for their perpetuation of their different form, their distinct species. All species here constitute the

order given nature by God's constitutional work in that week, and so no new species originate in his administrative working through nature since.

The Dewey–Mayr historiography has little to say about such medieval authors beyond emphasising their loyalty to Plato and Aristotle. That historiography can not therefore take properly into account what happened when seventeenth-century philosophy and science developed conscious replacements for that particular Greek heritage.

13 The Long Run: The *Origin* and Alternatives to Platonism

René Descartes, before midcentury, is the first cosmologist to have nature ordered by a few, universal laws for all matter in its motions, rather than many laws for many forms in their diverse, specific embodiments. By the next generation, a devout Christian, Robert Boyle, could be drawing on both Descartes and the Epicurean legacy in articulating a mechanical philosophy of nature that explains away the origins of Aristotelian forms as outcomes of differences in the size, shape and motions of bodies' minute, component corpuscles, differences that may be originally due to God's working rather than to nature's (Westfall 1971).

By the time one gets to Boyle and his friend Newton, the Dewey–Mayr historiography is paying a big a price in credibility for its ignoring of Greek, especially Epicurean, alternatives to Plato and Aristotle; and the credibility is never recoverable as one turns to the mid-eighteenth century. Then, Georges Buffon, drawing on Newton rather than Descartes for his account of the universal laws of motion, and lawful forces of attraction and repulsion as universal causes of those motions, upheld the original, secular Lucretian heritage in giving God no role in species origins (Roger 1997). For Buffon these are natural effects worked by spontaneous generations of founding individuals in parentless productions spread over many millenia, with the greater heat of the early earth making even large mammals spontaneously generable tens, may be hundreds, of thousands of years ago. So, Buffon breaks with Newton's protégé, William Whiston, whose account of the earth's formation and first furnishing with life conformed to Biblical texts and chronologies, and appealed to miraculous exercises of divine power to cause various productions, including species origins, productions taken by Whiston to be beyond the competence of ordinary, lawful forces and motions.

For Buffon laws of nature are still laws for gravitational and other forces; they are still laws for matter's motions. By Darwin's day, however, laws of nature are often dissociated from matter, so that Wallace, in 1855, could disagree with Lyell about the law, in the phrase he took from Lyell, regulating the introduction of new species, and could do so without any heed to any agreements or disagreements he may have had with Lyell on matter and motion. Cartesian or Newtonian matter, like Platonic and Aristotelean form, is then no longer an inherent, requisite grounding for any botanist's, zoologist's or geologist's commitment to the lawfulness of nature. Darwin says it accords best with what is known of the laws impressed on matter to believe that species have originated within the natural, lawful order; but in so saying he is not referring species origins to any laws for matter; he is only arguing that if the orbiting of planets and falling of stones are taken to be governed by laws given by God—and revealed by Newton—to govern all material bodies' motions, then it is only consistent to accept that species origins are governed by laws too, laws that he is claiming to discern, and so not the laws Newton revealed.

Darwin could make no precise invocation of one precedent set by Newton. Natural selection is a lawful not unlawful, miraculous cause, because it results from lawful

variation, heredity and superfecundity; but Darwin specified no one law for natural selection itself, no law that is to this cause as the inverse square law is to the Newtonian force of gravitation. On Darwin's view, species arise within the rule of law because natural selection does. Some reviewers who were physicists thought this claim for lawfulness too far from the confirmable, quantitative precision they expected in formulations of laws in their own science; but Darwin's fellow geologists, botanists and zoologists tended not to have those expectations and were willing to accept that, if his theory was true, then species origins were within the rule of natural law.

As for species, the Dewey-Mayr historiography is again mistaken in recognising too few of the fundamental innovations in the two centuries before the *Origin* appeared. Aligning himself with his friend Boyle, John Locke (1689) defended a view of species that made no appeal to Platonic or Aristotelian forms, in drawing instead on the corpuscularian mechanical philosophy. Plato's account of kinds as forms had covered man, horse, gold, justice and triangle, Locke's account covers the first three only. For Locke, the nominal essence of a species is the combination of observable qualities signified by the specific name; its real essence is the unobservable, inner corpuscular constitution causing those observable qualities.

After Locke but well before Darwin, different sciences decided that there were different kinds of kinds. Chemists now held elements, mixtures and compounds to be different kinds of kinds. The old trichotomy of animals, plants and minerals was replaced with the dichotomy between the living, organised beings, plants and animals, and the rest including the mineralogists' and chemists' domains. Conformably with this shift to this dichotomy, it was thought that distinctions among species of plants and animals were very different from distinctions among mineral sorts and chemical elements. A new understanding of animal and plant species arose owing much to both the unbiblical, Lucretian Buffon and his much more biblical and entirely unLucretian opponent, Linnaeus, the Swede who had convinced many that sexual reproduction could well be going on in all and only living beings. There were various versions of this new understanding, but most naturalists appealed, in differentiating among species, to questions of descent and interbreeding as well as resemblances in inner structures or outer parts, questions with no obvious place in mineralogy and chemistry. Cuvier lent his authority to taking a species to be an assemblage of all those individuals similar enough to be assumed to have descended from one distinct original stock. On any such view of species an early-nineteenth century ethnologist, such as Prichard, in deciding whether all the varieties of mankind are varieties of one species did not understand himself to be deciding about one or more Lockean nominal or real essences, but about interbreedings and true breedings, and about geographical as well as morphological indications of an ancestral unity of the original human stock. Among geologists, Lyell drew most extensively on these ethnological views in treating generally of all species, human and otherwise; and he provided decisive instruction for Darwin's earliest views as to what species are.

At Oxford in the early decades of the nineteenth century, Edward Copleston, Richard Whately and the young John Henry Newman were among those who were not students of natural history, and who were moving away from the study of Locke, not because he was too passe but rather too modern (Turner 2002). For in Locke's place they wanted to give Aristotle more attention. This move led to Whately reviving a subject left aside by Locke: logic, with Aristotle as its first and greatest master. Now, according to this venerable logic, Whately explained, a mastiff dog is of the genus dog and of the species mastiff, one of the divisions of this genus. However, Whately acknowledged that in natural history an entirely different classificatory assignment would be made, in accord with naturalists' quite

different notion of a species as an assemblage of individuals similar enough that they may be presumed to have descended from a single first stock; and Whately is well content to defer to the authority of naturalists on this whole topic. So, even when the logic of Aristotle was being revived academically, he was not always taken to trump any innovations in natural history.

Consider, too, the revivals of Plato, and of his ancient Greek follower Plotinus, studied in Germany by the young philosopher Schelling who would later be a source for Agassiz's Platonism; and consider Schelling's English emulator, not to say plagiarist, the young Coleridge, himself later an influence on Whewell (Ruse 2012b). These were revivals not survivals, so they are not confirmations of the Dewey-Mayr claim for two millenia of unbroken, unchallenged Platonic and Aristotelian dominance of thinking about species.

Dewey and Mayr lead us to expect some moment when, before writing the *Origin*, Darwin broke with such a dominance. Certainly Darwin, in his comparative anatomy never embraced Whewell's friend Owen's (1849) Platonic sympathies. But earlier, in engaging Lyell and Lyell's version of Lamarck, and in going on from there, Darwin was not having to defy any hegemonic Platonic or Aristotelian dominance in working out how to think for himself about species and their origins; so the *Origin* was not the outcome of any individual liberation from ancient philosophical prejudice.

The Dewey–Mayr thesis has been invaluable in two ways: in viewing the *Origin* as a successor to Plato's *Timaeus* as well as successor to the biblical *Genesis*; and in recognising Greek metaphysical and cosmological themes in the responses to the *Origin* from the likes of Owen, Agassiz and Whewell. However, if made into a more comprehensive historiography it ignores or misinterprets too much of what happened after Plato and before Darwin.

14 The Long Run: The *Origin* and Capitalism

Another objection to any Dewey-Mayr historiography is that it concentrates too exclusively on intellectual legacies and innovations, and so does not study the relations between the *Origin* and its social and economic contexts. To understand these relations, what is needed, it may be said, is a different view of the long run. One way to take such a different view is to start from a large, narrational abstraction, such as the transition from a traditional, feudal Europe to a modern, capitalist Europe; and to relate this transition to the shift from medieval integrations of a sudden, recent supernatural Hebrew creation with Greek stasis and hierarchy, to Darwin's account of a slow, gradual, natural progress of life over eons of descent and diversification. Here it is customary to talk of evolution and revolution. The *Origin* is read as a revolutionary replacing of creation with evolution, and so as the decisive text in an evolution revolution. A final step in this historiographical direction is to identify the social and economic revolution that provided the context for this evolution revolution. Here one choice has often seemed inevitable: the British industrial revolution commonly dated from around 1760–1840. With this step taken, a coherent evo- revo-indy-revo historiography is complete in outline. In going beyond that outline one may relate evolution to industrial production via the idea and ideology of progress, and relate natural selection to industrial capitalism via the idea and ideology of competition (Young 1985; Desmond and Moore 1992).

Any such line of historiographical reflection plainly has advantages in enhancing understanding of the wider, deeper significance of the *Origin*; not least because it integrates

the studies made of Darwin and his work by historians of science with studies by historians in other fields.

There are, however, two difficulties with any evo-revo-indy-revo historiography. First, the notion of a Darwinian revolution, or even of an evolution revolution, is hard to square with the complexities and diversities in pre-Darwinan and post-Darwinian thought; second, the notion of a British industrial revolution is not now as uncontestable as it was in its heyday.

These two difficulties suggest that relating the *Origin* to the long run of British capitalism needs to depart from past, evo-revo-indy-revo, precedents (contra Ruse 2009). For a start, consider the variety of British capitalisms in the eighteenth century. Early in that century there was already a socially integrated, economically burgeoning and politically powerful alliance between the landed rentier, agrarian capitalism, especially of the eastern and southern counties, and the financial capitalism of the City of London (the British Wall Street) with its banking, stock exchanging, insurance, accounting and other financial services. This domestic alliance was moreover dominant in the funding and directing of overseas colonial investments, dominant therefore in driving Britain's imperial capitalism. All the developments associated with industrialisation and urbanisation in the industrial revolution decades were consequently far from displacing the prior prominence of agrarian, financial and imperial capitalisms, and for at least four reasons. First, industrial capitalism was strongest in the less affluent and less fertile northern and western regions. Second, the capitalism of land and finance was typical of upper-class aristocrats and gentry, and of the gentlemanly upper middle class, while industrial capitalism was more typical of the middling ranks of the middle class. Third, the largest fortunes amassed from land, finance and empire were at least as great as those derived from the new machinofacturing. Fourth, dominance of parliamentary rule by the older capitalist interests persisted throughout the industrial revolution decades.

To relate Darwin's life and work to these socio-economic trends and tendencies, it suffices to follow the theme of land capitalism, on turning first to Darwin's family and then to his theories. His grandfather, Erasmus Darwin, was the younger son of a younger son of a landed estate owner, in Nottinghamshire near the border with Lincolnshire, the eastern county often thought to have the nation's most profitable land. This grandfather's second wife was the widow of a Derbyshire landowner. Charles Darwin's father Robert was a doctor in Shropshire but he bought Lincolnshire farms as investments, and lent his son Charles money to buy one too. Massively wealthy, mainly from extensive wheeling and dealing in Shrewsbury real estate, but perhaps also from his father marrying into landed wealth, Robert Darwin lent his brother-in-law, Josiah Wedgwood the second, of pottery dynasty fame, the equivalent of two or three million in today's dollars, so that he could buy a big house and estate and be a landed gentleman as well as a captain of manufacturing industry. Charles Darwin eventually married Josiah Wedgwood's daughter, Emma, but earlier just might have married the daughter of a nearby landed, titled squire, another big borrower from Robert Darwin. Five years or so after his voyage, Charles Darwin moved south and east a few miles, on leaving life in London to reside for his final forty years in a former parsonage with a few acres in rural Kent. His wealth compared well with his father's. His large and profitable investments, brokered in the City, rarely reached factories, while railways were among his favorites, as they frequently were with landed capitalists, their property often made more valuable by the railway companies' leasings, purchases, constructions and transportation facilities.

So, Darwin's family history hardly fits the expectations raised by invocations of the industrial revolution with its exemplary new machinofacturing sites in northern cities such

as Manchester and Leeds. The voyage of the *Beagle* was also much closer to the capitalism of land and empire. Its official Admiralty mission included coastal surveying that would facilitate British trade with South American countries newly freed from Spanish rule, and so bring those regions not into British possession but into her informal empire. The extremely wealthy captain, FitzRoy, was the grandson of a duke of large estate. The science of empire as land was geography, including ethnology. Darwin's main geographical mentors during those voyage years, Humboldt and Lyell, were both from families with landed wealth. The main precedent for Lyell's geology was the Scottish James Hutton's (1788) theory of the earth, a theory partly grounded in its agriculturist author's views on the maintaining the fertility of farm land. In their conception of species, Lyell and Darwin were principally indebted to Prichard and his mentor Blumenbach who had brought interpretations of variation in domestic species to their ethnological views on the varieties and unity of mankind, in a synthesis of agrarian and imperial theories and practices relating directly to the capitalisms of land and of empire but not to manufacturing or machinofacturing industry. Darwin's early theorising, before he had his theory of natural selection, his theorising about descent and diversification, was often dominated by geologico–geographical views of dispersions, migrations, invasions and conquests. These echoes and reflections of empire are likewise far stronger than any echoes and reflections of industry.

When Darwin responds to Malthus he draws, not on the parson's gloomy take on England's domestic population, but as one theist extending another's optimistic teleology and reassuring theodicy for superfecundity and the lands and peoples of ancient empires. On the origins as on the extinctions of species, Darwin's new Malthusian insights were confirming his Lyellian geographical and ecological preoccupations with territorial winnings and losings, like those that empires depend on, rather than the winnings and losings in making and marketing decisive in industry. Two months on from that response to Malthus, Darwin had his selection analogy with its manifest links with agrarian capitalism. The alignment with Malthus may look like an alignment with industry; but Malthus was a defender of the Corn Laws, provisions for protecting the agricultural interest and resented by industry. The main connection between his views on population and on political economy was land use for food production, which he, following the eighteenth-century French physiocrats, gave priority over all other productions; and which, in disagreeing his friend Ricardo, he took to give priority to land as capital. When Darwin drew later on Adam Smith's doctrine of the division of manual labor as enhancing production and profit in the factory system, he integrated this industrial doctrine with an agronomical teaching: that more vegetation can grow and be harvested from any area of ground when many species, not just one, are grown there.

Even a quick glance at the socio-economic contexts of Darwin's living and thinking shows the prominence in both of agrarian, financial and imperial forms of capitalism, a prominence inconsistent with standard evo-revo-indy-revo historiographies and their invocations of a British industrial revolution. Many historians of science today, themselves urban dwellers in industrially-advanced societies, and concentrating their historiographies on what was new in Darwin's science, may presume that life on the land in Darwin's day was much too conservative, compared with life in town, to be pertinent to anything as novel as the teachings of the *Origin*. However, no such presumption can cohere with any comprehensive study of Britain's capitalisms as they have developed over the last four or more centuries. Obviously, industrial capitalism was not irrelevant to Darwin's theorising, if only because the various forms of British capitalism interacted with one another. However, in enquiring into socio-economic contexts for this theorising, the emphasis cannot continue to be on industrial revolution historiographies for Darwin's Britain; for

those historiographies are themselves no longer uncritically sanctioned by social and economic histories. The good news is that those histories can lead historians of science to fresh ways to place Darwin's book in its original contexts.

15 Concluding Remarks About Historians, Philosophers and Scientists

Exceptionless generalisations about historians of science are no more to be expected than universal truths about historians of politics or of art; but there are some commonplaces that many historians of science accept. One slogan often worked into introductory teaching says that we should understand a book like Darwin's *Origin* in its own time and on its own terms. Darwin was living and thinking in Britain in the middle of the nineteenth century not in France a century earlier or in Canada a century later. For Darwin's talk about species, about heredity and variation and about chance and design was conditioned by the meanings those terms had there and then. To suppose otherwise is to be unhistorical about his book. Another slogan is hardly less obvious. History of science studies science with the people left in. School science textbooks present their teachings as factual or theoretical conclusions about the world, but not as the products or properties of those people who first came up with those conclusions. Historians of science do not make such detachments of science from people. Moreover, once some people, the scientists, are brought into the story many more have to be included: the teachers of those scientists, their families, their employers, their supporters, their opponents, their religious mentors, their political leaders, and so on without limit: the whole society, its cultures, its institutions, its ideologies, its divisions of rank or class, its economy and so on. This historiographical holism obviously makes for challenges. Granted, everything affects everything, and so anything may throw light on anything else: the agendas of Christian missionaries in Tahiti, or the peculiarities of Scottish higher education, or controversies in aesthetics may throw light on Darwin's writings about animals and plants. But did not some things bear more directly and sustainedly on the man and his work: Lyell's geology or Owen's comparative anatomy or the precedents set by his grandfather, Erasmus Darwin? Yes, perhaps so; but many historians of science are unwilling to generalise in advance about what have always been primary factors and what secondary, preferring to assume that detailed research into a particular topic will indicate what was so in that case.

These preoccupations of historians of science can introduce a couple of contrasts. For consider how scientists rather than historians often approach Darwin's book. Scientists are concerned with the contribution it has made to the growth of knowledge. In other words, they ask what parts of our knowledge today are owing to Darwin's *Origin.* What was true and new in that book, and so what can it do for us now? That is the question: not the historians' question: what did it do for Darwin then? Again, by contrast with both historians and scientists, philosophers do not ask what it has done for someone in particular, but rather what could it do for anyone at any time. How far, that is, do its premises support its conclusions? And what assumptions do its arguments make and what implications do its conclusions entail? Plato's dialogues expound for all who read them the views about reality, knowledge and goodness that constitute the system of ideas we call Platonism. Likewise, philosophers tend to say, with the *Origin* and those ideas about animals and plants that we call Darwinism.

Staying with this threefold contrast between historians, scientists and philosophers, let me address a limitation in what I have written in this essay. For I have written mostly about the composition of the *Origin*, about its sources and about how it related to the short and

the long run of previous thinking and how it was aligned socially and economically; only occasionally have I discussed how the book was received, how it influenced people in its own time and since. There is now a great deal known about how Darwin's views were welcomed or rejected, how they were positively or negatively influential among all kinds of people at all sorts of times and place: a century and a half ago in the Vatican or in the US Geological Survey, or more recently in the Tennessee schools or among the Nazi leaders or among evolutionary geneticists or behaviorist psychologists or pragmatist philosophers, or among novelists, poets and musicians or clonal-selectionist immunologists. Again, when historians study such influences they are more mindful than are scientists and philosophers of some obvious asymmetries: Darwin can influence Stephen Gould or Richard Dawkins, but they can not influence him because he came earlier. This truism may seem to truistic to be interesting; but some scientists get close to forgetting it when they imply that Darwin did what he did because his role in the growth of knowledge was to prepare the ground for twentieth-century evolutionary biology. Some historians of science fortify themselves against such forgetfulness by formulating their interpretations of Darwin's aims and intentions using only terms, concepts and categories that Darwin himself could have used in his time and place. In its strictest versions this policy would ban all talk of genotypes versus phenotypes and of the scientific discipline of evolutionary biology. Such strictness may seem unduly restrictive; but we do not object when historians of American politics refuse to talk of right and left or of Democrats versus Republicans in writing about the early colonial era.

One issue here concerns historians' duties toward what is going on at present. A commonplace says that we need to study the past in order to better understand the present; and that this commonplace applies to the past and present of science no less than to the past and present of economics or of war and peace. A couple of reflections may serve to make this commonplace worth qualifying if not questioning. First, this commonplace cannot licence projecting present science back on to past science, projecting, say, the twentieth-century genotype-phenotype distinction into our reading of the *Origin*. Quite the reverse in fact; for the light the past can throw on the present is diminished if we have read the present back into the past so that it becomes more present and less past, and so less rich in instructive contrasts with the present. Second, there can be coherent reasons for studying the past apart from a wish to get light on the present. The past is the only long run we have access to; the present is a very short run, the future is longer but inaccessible. For many human activities, if not all, some of the most instructive features only show in the long run. Indeed the short run may mislead us about the activity: think of economics and the reasons economists have for studying very long as well as short run trends. Science is no exception to this generalisation. The work scientists do from one month or year to another may seem very little influenced by broader currents of social and cultural change; but once we ask how Darwin's life and work differ so strikingly from Gould's or Dawkins's we can see that a comprehensive answer would have to take in those broader currents, including religious and political changes far beyond the official agendas of scientific professionals.

Even these brief reflections on how historians, scientists and philosophers tend to approach the *Origin* may suggest that these three tribes can certainly interact and even collaborate fruitfully, but should not be in denial about the differences which may not divide but do distinguish them. Educationists, if that is an acceptable professional or disciplinary designation for many readers of this journal, may find the contrasts drawn here as so many complicating challenges they could well do without. Perhaps they will feel that access to the past of science as an educational resource today ought to be a straightforward matter of finding competent guides and reliable maps, and ought not to require confronting

a diversity of approaches and of schools of theory and practice. It will not be any comfort to be told that a few decades ago this diversity was often less conspicuous because many historians of science shared with their scientific and philosophical colleagues a positivist take on the nature and development of modern science, and because that interdisciplinary positivist consensus entailed that the past and present of science be related to one another in accord with positivist views of fact-driven and physics-led progress in the sciences of life, mind and society. That consensus was never unchallenged; think only of the Hegelians and Marxists of those days; but in our time that consensus has been replaced by no comparable even partial consensus among historians, philosophers and scientists; if only because these three tribes are not united and consensual within themselves. And I dare say that this is true for educationists also. As academic disciplines go, history of science is not very disciplined; and on a major topic such as Darwin and the *Origin* there is certainly no party line, no received view. To be invited, as I have been, to write as historians of science tend to write about that book is not to be invited to pose as a spokesperson for a party line, but invited to take advantage of the absence of any such constraint. Long may historians of science work to keep that advantage in play.

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