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6 Is the theory of natural selection independent of its history?

I THE CULTURAL CONDITIONING OF DARWIN'S THEORY

Machines, competition, empire and progress fascinated the Victorians. One of the most famous scientific theories of the era, Charles Darwin's theory of natural selection, tells of machine-like organisms that compete, colonise and improve. To notice resemblances such as these, between the context of Darwin's theory and its content, is nothing new. In 1862, Karl Marx, in a letter to his collaborator Friedrich Engels, wrote: 'It is remarkable how Darwin recognises among beasts and plants his English society with its division of labour, competition, opening up of new markets, "inventions", and the Malthusian "struggle for existence". It is Hobbes' "bellum omnium contra omnes" ["the war of all against all"].'[1] In our own day, debates over the cultural conditioning of scientific knowledge have made this old insight newly problematic.[2] This chapter attempts to clarify these new problems. Drawing on recent thinking about culture and science, it looks at how Darwin's social, material and intellectual culture conditioned the form and content of his theory of natural selection.

One view may be dispensed with at the start: that Darwin developed the theory of natural selection because he was a genius, and, since geniuses do not belong to mundane history like most people, it is pointless to ask about the cultural conditioning of his theory. There is general consensus among historians of science that talk of 'genius' does not so much explain scientific innovation as redescribe it.[3] In Darwin's case, moreover, two generations of scholarship have revealed how much the history of the development of his theory is

a social history. The pressing issue now is more subtle. We must ask whether, in fundamental ways, the theory of natural selection is nevertheless independent of the social history that brought it into being.

We can characterise two contrary theses. An *independence* thesis about the theory is the more traditional and intuitive of the pair. On this thesis, the resemblance between cultural context and theoretical content throws light on why a Victorian first developed the theory. Features peculiar to Victorian culture primed Darwin to recognise a timeless truth about nature. But the development of the theory was inevitable – the priming just accelerated the process.[4] There was only so much that could be learned about plants and animals before a conclusion in favour of natural selection became inescapable. Other individuals, belonging to different societies with different histories, would have developed the theory sooner or later. Since lots of different social histories would have yielded the theory, it is independent of any particular history, including the history that happened to yield it.

On the other side is an *inseparability* thesis. It is a deliberately provocative newcomer. On this thesis, the close match between context and content shows that the theory of natural selection was not at all inevitable, but a contingent result of a unique social history. The theory's existence depends crucially on features of the Victorian context unlikely to have been replicated elsewhere. Since the theory would never have existed apart from the trends and events that in fact led Darwin to develop it, the theory is not independent, but inseparable from its history. Furthermore, if Darwin, or someone much like him, with similar relations to a similar cultural context, had not developed the theory of natural selection, the biological sciences would now be different, but no less successful.

After first sketching the social history of Darwin's theory, I shall examine some arguments for and against its independence from its historical matrix. At bottom, to ask about the independence of the theory is to ask whether the assumptions and decisions that produced it were both necessary and such that no one outside Darwin's matrix would likely have made them. The third section below explores this point about assumptions and decisions in quite a general way. The fourth section looks at one of Darwin's assumptions in particular – his assumption that the concept 'adaptation', as he

understood it, deserved to be at the centre of theorising about the origin of species. The fifth section then looks at one of Darwin's decisions in particular – his decision to concentrate on developing the Malthusian theory of natural selection once that theory had emerged in his notebooks. I argue that the stability of Malthusian struggle in Darwin's theorising is better accounted for on the inseparability thesis. In place of the standard, Marxian version of that thesis, however, the sixth section offers an alternative version, emphasising Darwin's views on method.[5] The chapter concludes with some reflections on how debate over the independence of Darwin's theory from its history relates to recent controversies in that most Darwinian science, evolutionary biology.

II VICTORIAN POWER, DARWINIAN KNOWLEDGE

Was Darwin a genius? Not in his own estimation.[6] His notebooks indeed show scant sign of those flashes of insight which, since the Romantic era, have been associated with the scientific genius.[7] But however high one's regard for Darwin's intellectual powers, those powers did not enable him to transcend his outward circumstances. He did not develop the theory of natural selection by communing with the truth about nature, isolated from the bustling world around him. At every step towards the mature theory, worldly power enabled cognitive advance.[8]

Three steps in particular can stand for the whole, complex sequence. First, there was Darwin's coming to believe, within half a year of his return from the *Beagle* voyage, that new species arose through natural causes acting on pre-existing species: the transmutation thesis. If Darwin had never persuaded himself that transmutation was true, it is hard to see why he would ever have bothered with theorising about its causes at all, much less with developing the theory that natural selection was its principal cause. Darwin seems to have committed himself to transmutationism in the course of reflections on some surprising news about his *Beagle* collections. In the Spring of 1837, the London-based Darwin learned, among other things, that many of his Galapagos specimens belonged to species found only on the Galapagos archipelago. Moreover, those species often belonged to genera peculiar not to other rocky oceanic islands around the world, but to the South American mainland, where the

lush tropical conditions could hardly have been more different from the conditions on the Galapagos. For Darwin, the best explanation for this taxonomic and biogeographic puzzle was that the Galapagos species had arisen through transmutation from mainland species ancestral to the ones currently inhabiting the mainland.[9]

Darwin had this crucial puzzle to ponder, then, because he had travelled on the *Beagle*, had collected certain birds from the Galapagos, and those birds had been classified in a certain way. Each element in this package has its place in a uniquely Victorian order. The *Beagle* voyage was not, after all, a quest to discover the origin of species. The idea for the voyage was Captain FitzRoy's. He had returned from a previous trip to South America with four Fuegians, and now wanted to take the three survivors back, to serve as Christian paragons among the savages. The Admiralty funded the new voyage for its own purposes, because better maps of the South American coastline would benefit trade and so increase national treasure. Darwin was no mapmaker, and the ship already had a naturalist; but Darwin was refined and rich – enough to pay his own way – and therefore a suitable dining companion for the aristocratic captain.[10] Once aboard, Darwin hired a crew member, Syms Covington, to act as a personal servant in collecting plants, animals and fossils.[11] Back in England, Darwin eagerly handed over his collections to museum-based experts in taxonomy. Such deference on the part of voyaging collectors had made the museum collections vast; and this vastness in turn underwrote the authority of expert classifications.[12]

Theoretical content and wider context likewise intertwine at a second step: Darwin's turning to the domestication of animals and plants for insights into transmutation. Darwin began making incursions into the breeding literature soon after opening his notebooks on the transmutation problem. Later, as an established gentleman of science, he went along to the breeders' meetings. The enterprise of plant and animal breeding was as far advanced in Darwin's Britain as anywhere else in the world. Well organised and intensely competitive, breeders kept tabs on their art and each other through periodicals, clubs, societies, exhibitions and prize competitions. Darwin's wealth enabled him to inquire about trade secrets without posing a threat to profits. The breeders may even have seen in Darwin's interest a means of elevating the cultural standing of breeding.[13] Famously, an analogy with stockbreeding would become

the centrepiece of Darwin's public presentation of the theory of natural selection in the *Origin of Species* (1859).

A third and final step to consider is Darwin's so-called 'Malthusian moment'. Darwin developed the theory of natural selection over several months beginning in the autumn of 1838, after reading in the political economist Thomas Robert Malthus' *Essay on the Principle of Population*. Malthus had written in part to dampen utopian hopes aroused in the wake of the French Revolution. He had claimed to show that, other things being equal, human populations outgrow available subsistence, bringing hunger, war and other miseries.[14] Extrapolating from Malthus, Darwin came to believe that population pressures in nature were so intense that all plants and animals were locked in a struggle for existence. Given inheritable variation among those struggling plants and animals, over time there emerged, slowly but surely, new and better adapted species.

Later Darwin would recall picking up Malthus' *Essay* 'for amusement', as though, on a dull afternoon, he had reached for whatever was near to hand.[15] Maybe so. But Malthus was on a lot of minds at the time. The Whig party, political home for the Darwins, the Lyells and other gentlemanly families, had recently come to power, and in the name of Malthus was introducing harsher measures for the provisioning of the poor. Darwin had long been familiar with arguments in favour of these changes. While he was on the *Beagle*, his sisters sent him pamphlets full of pro-reform propaganda. Their author, Harriet Martineau, soon became an acquaintance. Malthusian doctrine was the stuff of dinner conversation at London parties – and Darwin was there. When Darwin at last read Malthus for himself, the London papers were full of news of riots, marches, workhouse burnings and other protests against laws acknowledged on all sides as Malthusian in spirit.[16]

So Darwin's theory of natural selection was no gift of sheer, sublime, solitary genius, but in several key respects a product of Victorian culture. This conclusion is not obvious. We have contextualist historians of science to thank for it. Their labours have not so much ended the debate over context and content, however, as raised its level. Aware as never before of the theory's ties to its historical matrix, we can now pose the difficult issue of the independence or inseparability of the theory from that matrix.[17]

III DARWIN'S ASSUMPTIONS AND DECISIONS

To bring this issue into sharper focus, it helps to examine Darwin's assumptions and decisions: assumptions about nature and knowledge, and decisions about, among other things, how to resolve conflicts between theories held and observations made. On the inseparability thesis, there was nothing inevitable about making just the assumptions Darwin made, or resolving conflicts in just the ways he did. But the assumptions made and the resolutions decided upon led Darwin to work out his theory of natural selection. This theory in turn set the biological sciences in certain directions rather than other ones.

What assumptions structured Darwin's investigations? One was that a true theory of species origins would explain adaptations.[18] Another was that a true theory would conform to the old *vera causa* ideal, referring only to presently acting and independently attested causes.[19] Neither of these assumptions was obviously reasonable to all those concerned with being scientific about the history and diversity of life. Consider the assumption about admissible causes. In Germany, following Goethe and others, the morphologists dealt in archetypal patterns. In France, Cuvier had urged that causes now diminished in power conditioned the succession of animal types recorded in the rock strata. Even in England, where the *vera causa* ideal was associated with the illustrious Isaac Newton, strict adherence was unusual, not least among geologists. Yet Darwin made the ideal his own, in imitation of his geological mentor Charles Lyell. We need, then, to ask whether something specific to Lyell's microcontext explains his *vera causa* enthusiasms. The sixth section of this chapter makes the case for the Whig reform drive, in the sciences and outside them, as the key.[20]

Underlying assumptions bind a theory to its context. So do resolutions of conflicts between theory and world. Darwin's reading of Malthus eased such a conflict, and in doing so directed Darwin's theorising towards natural selection. The conflict concerned the causes of species extinction. According to Lyell, the struggle for existence, driven by population pressures, was the *vera causa* of species extinction – that is, species become extinct when a delicate competitive balance is upset by environmental causes such as changes in climate. Throughout 1837 and 1838, Darwin was still

questioning this theory as hard to reconcile with those cases, familiar from his observations in South America, of the big mammals of yesteryear becoming extinct apparently without any such changes. There did not seem to be evidence for Lyell's environmentalist explanation. After reading Malthus, however, Darwin changed his mind. With a newly vivid appreciation for how intense the struggle for existence was, he was able to excuse Lyell's theory its evidential problems, on the grounds that environmental changes far too small to leave evidential traces might nevertheless cause some species to drive others to extinction.

Darwin went on to develop the theory of natural selection – a theory complementing this account of extinction – by focusing on what happened not to the losing, extinct species, but to the winning, surviving species; in particular, to those individuals in the winning species whose variations made them especially strong competitors.[21] But suppose Darwin had not been immersed in Malthusian conversations in London, and had never happened upon Malthus' *Essay*. He might have resolved the conflict over extinction in the opposite way, concluding that, in the light of the geological evidence, population pressure did not make species liable to extinction. He might then have continued working on his earlier theory of adaptive species formations. In Darwin's view at that time, this non-Malthusian theory, while evidentially problematic, did conform to the *vera causa* ideal. Perhaps he would eventually have published that theory. Or perhaps he would have judged the problems to be so severe that he would have given up on it, and abandoned theorising about species origins altogether.

Let us grant for the moment that no-one but Darwin, in his context, would have made just those assumptions about species origins, or decided, on Malthusian grounds, to resolve the conflict between Lyellian theoretical struggle and earthly evidence in favour of the former. What are the signs that, without those assumptions and that decision, the theory of natural selection would never have been developed? The need to show a one-to-one relationship between aspects of the theory of natural selection and the history of Darwin's development of it is the most formidable challenge confronting the inseparability thesis.

Not the least part of that challenge is to explain away the case of Alfred Russel Wallace. Wallace did not share Darwin's privileged

background or steep himself in adaptationist natural theology at Cambridge. Yet Wallace formulated a theory of species origins close enough to Darwin's own that Darwin feared he had been scooped.[22] This famous example of simultaneous discovery in natural science appears to lend strong support to the independence thesis. Darwin found his way to natural selection by one route, and Wallace by a different route. The lesson seems to be: if you think hard about species origins, then it does not matter how you travel, you will reach the theory of natural selection in the end.

On closer inspection, however, the Wallace case offers at least a few openings to those sceptical about the independence of the theory from its history. One move would be to deny that Wallace did, in fact, 'co-discover' the theory of natural selection. Rather, he came up with a theory quite different from Darwin's, and Darwin's overreaction in 1858 has misled historians ever since.[23] Allowing instead that, as Darwin thought, the theories are indeed basically the same, one might conclude that, for all their differences, Darwin and Wallace were similar-enough products of Victorian culture. Wallace, after all, was not merely a student of biogeography, but, like Darwin, committed to Lyell's distinctive view that the history of changes on the surface of the earth held clues to animal and plant distribution. Indeed, like Darwin, Wallace arrived at a branching evolutionary tree from dissatisfaction with Lyell's account of the timing and placing of species origins as determined solely by the principle of adaptation to conditions.[24]

There are other common inheritances. Not long after discovering a geographic boundary between human races in the Malay Archipelago, Wallace recalled his own reading of Malthus, and articulated a new Malthusian explanation for adaptive evolutionary change. Wallace had with him the 1845 edition of Darwin's *Journal of Researches*, and may have been responding to a Malthusian passage on species extinctions in that book. Or perhaps a chain of association in Wallace's fevered mind – he was ill at the time – led his thoughts from the racial boundary he had just discovered to the boundaries he drew while working as a land surveyor in England and Wales in the early 1840s. It was around that time, amid general discontent over the Poor Law reforms and rising English–Welsh tensions, that Wallace had first read Malthus.[25] So the Wallace case, awkward though it is, may not be fatal to the inseparability thesis.

IV THE DARWINIAN CONCEPT OF ADAPTATION

Some of Darwin's assumptions concerned concepts, classifications, categories – or, in the philosopher's term, kinds. One kind, 'species,' figures in the title of the book that introduced the theory of natural selection, *On the Origin of Species*. Some say the title was false advertising, as Darwin denied that individual plants and animals come sorted into species. In his sceptical view, it was naturalists, not nature, that divided species from one another.[26] By contrast, he took for granted that the individual *traits* of plants and animals come sorted naturally, into traits that are adaptations and traits that are not. For Darwin, in other words, adaptations formed a natural kind.[27] Moreover, they represented one of the chief explanatory challenges before the transmutation thesis. In his introduction to the *Origin*, Darwin wrote that, however impressive the general grounds for favouring transmutation, a transmutation theory would be 'unsatisfactory' unless it could explain 'that perfection of structure and coadaptation which most justly excites our admiration'.[28] Later in the book, he addressed the challenge of an especially complex adaptive structure: the eye. 'It is scarcely possible to avoid comparing the eye to a telescope', he wrote. Just as humans have perfected the telescope gradually, so, Darwin argued, natural selection had gradually perfected – but to a much higher degree – 'a living optical instrument'.[29]

The mechanical concept of adaptation exemplified in Darwin's account of the eye has a history.[30] The idea that different traits suit different plants and animals – that fins suit fish to swimming, say, and wings suit birds to flying – goes back at least to the ancient world. Aristotle wrote of the purposes fulfilled by the parts of animals. Far from ancient or universal, however, is the idea that traits suiting their various bearers under their diverse conditions of life should be grouped *together*, privileged as the outstanding facts about organisms and conceived as mechanical contrivances. That idea is the product of one culture: early-modern Britain. To understand why Darwin gave pride of place to a mechanical conception of adaptive traits, we need to recall a British tradition of natural history and natural theology, its themes and its setting.[31]

In the late seventeenth century, two members of the Royal Society published influential works of natural theology. Robert Boyle's

A Disquisition about the Final Causes of Natural Things (1688) and John Ray's *The Wisdom of God Manifested in the Works of the Creation* (1691) argued that the abundant evidence of design in nature, and especially in animate nature, showed the existence, intelligence and goodness of God. Boyle and Ray set the model for subsequent natural historical and natural theological writing in Britain. From the Middle Ages to the early-modern period, the study of animals had been largely the study of revered texts and preserved specimens. Now it involved active observation of living creatures in the wild. As for natural theology, earlier design arguments had not dwelt especially on the adaptedness of the parts and instincts of organisms. As Boyle explained, however, the proposals of Descartes had made the regularly cycling heavenly bodies rather less attractive as evidence for design than they had been previously. Traits fulfilling some purpose in the lives of organisms became the best evidence by default.[32]

Adaptations were now regarded as constituting a kind in their own right, as the features of nature in which God's signature was most clearly legible. They were described as products of the highest possible order of craftsmanship. 'I never saw any Inanimate production of *Nature*', marvelled Boyle in his *Disquisition*, '. . . whose contrivance was comparable to that of the meanest Limb of the dispicablest Animal: and there is incomparably more Art express'd in the structure of a Doggs foot, then in that of the famous Clock at *Strasburg*.'[33] Devout naturalists in the eighteenth century catalogued the adaptive parts of organisms, describing those parts as machines engineered with admirable skill.[34] Talk of contrivance and clocks remained central, sustained in part by the success of British workshops at contriving the most precise clocks and watches in the world. Along with steam engines, spinning mules and other cunning devices, precision timepieces were instruments of British industrial and imperial expansion.[35] Again following Boyle and Ray, British writers on natural theology approved. In their view, the natural world had been designed so that industrious humans would benefit from its exploitation. To admire the craftsmanship of God was at the same time to admire the social and commercial arrangements that facilitated such efficient fulfilment of God's wishes for humankind.[36]

Boyle and Ray wrote at the end of a turbulent period in British history. In their books, the argument from design became a means of allying the new empirical science to Christian consensus and

the prosperity it fostered. By emphasising the study of adaptive contrivance in living creatures, they created a useful role for British science in promoting national harmony. Men and women awake to the providential character of living nature and commercial society would be less prone to atheism and revolution.[37] Boyle and Ray's most famous successor, William Paley, continued these apologetic efforts, issuing his famous *Natural Theology* (1802) at a moment of renewed fear of revolution – this time imported from France.[38]

In his most famous argument, Paley concluded that organisms, with their many parts contrived to serve particular ends, could no more come into being without a designing intelligence than could functioning watches.[39] Paley's book was one of the few to make an impression on Darwin when he was a student at Anglican Cambridge.[40] Not least impressive, it seems, was Paley's comparison of the eye with a telescope.[41] From Paley, and from other authors writing along similar lines, Darwin learned to view organisms as assemblies of separate adaptations, and to view adaptations as remarkable contrivances. For Darwin, the facts about adaptations, so conceived, became the outstanding facts about organisms, the facts a theory of species origins had to account for satisfactorily. Boyle's celebration of the scrupulously attentive 'Author of Nature' echoed in Darwin's insistence, crucial to his case for natural selection, that Nature preserves even the slightest advantageous variation in structure and constitution.[42]

The Darwinian kind 'adaptation' thus has a history rooted in the soil of British scientific, religious, social, commercial and political life.[43] We can gloss this historicity in two ways, with different consequences for independence versus inseparability. We might conclude that, thanks to events that brought British natural theology into being, and Darwin into contact with this tradition, Darwin came to recognise what adaptations truly are – the as-if engineered contrivances of natural selection. That recognition would have come sooner or later, since the kind is part of the pre-social order of nature. How the British came to recognise it had no influence on the kind itself. To that extent, the kind is independent of its historical matrix. Or we might conclude, on the contrary, that history, not nature, made the kind what it is. The theory of natural selection assumes a view of organisms and their parts that is peculiar to a time and place. The Darwinian kind 'adaptation' is inseparable from

Britain in the age of complex machines and counter-revolutionary theology. Other histories produced, and continue to produce, alternative ways of sorting the traits of organisms, ways no more or less in keeping with what we observe. Adaptation is not a natural kind, but a social construct.[44]

V THE MALTHUSIAN STRUGGLE FOR EXISTENCE

In Darwin's day, and to his nineteenth-century Russian readers in particular, the stamp of his context was most visible in his appeal to a struggle for existence identified as Malthusian.[45] Describing that struggle in the *Origin*, Darwin wrote: 'It is the doctrine of Malthus applied with manifold force to the whole animal and vegetable kingdoms.'[46] He argued that the diversity and adaptedness of species were the consequence of generations of struggle among organisms who had passed at least some adaptive variations on to their offspring. This argument for natural selection, developed between September 1838 and March 1839, emerged only after much previous and wide-ranging theorising on the causes of adaptive change. Once he had the argument, however, Darwin's allegiance to it never seriously faltered. How, then, to explain this stabilisation of Darwin's theorising around a doctrine as contentious as Malthus' population principle?[47] Why the decision to stick with Malthus?[48]

For some commentators, then and later, the best explanation is that Darwin stuck with Malthus in order to legitimate hierarchical relations of power in Victorian Britain. The explanation has rarely been stated this baldly. It derives from an analysis of ideology associated now with Marx.[49] In a diffuse way, of course, Marx's influence extends over all the territory covered in this chapter. Soviet Marxist historians helped pioneer the anti-genius historiography of the sciences.[50] Marx's most famous comment on Darwin's theory and his society, quoted above, was in part a comment on the naturalness of the kinds that appear in the theory.[51] It was not Marx but Engels who gave the classic Marxian reading of Darwin's Malthusianism:

> The whole Darwinist teaching of the struggle for existence is simply a transference from society to living nature of Hobbes' doctrine of 'bellum omnium contra omnes' and of the bourgeois-economic doctrine of

competition together with Malthus' theory of population. When this conjuror's trick has been performed, . . . the same theories are transferred back again from organic nature into history and it is now claimed that their validity as eternal laws of human society has been proved.[52]

If this was indeed what Darwin was doing, then his decision to stick with Malthus appears inseparable from its matrix. Making competitive struggle look natural is an ambition that makes little sense outside a social context where there is not only competitive struggle but potentially much discontent with the results. Nearer our own day, the historian Robert Young has similarly argued that, just as the theory of special creation was 'a theory suitable for a pastoral, agrarian, aristocratic world', so Darwinian natural selection, with Malthusian struggle at its core, was a theory 'which reflects a competitive, urban, industrial one'. For Young, the transition from natural theology to natural selection was but 'the substitution of one form of rationalization of the hierarchical relations among people for another'.[53]

To come to grips with this explanatory tradition, two quite different claims about Darwin, Malthus and legitimation need to be distinguished.[54] One is that Darwin in his theorising on species stuck with Malthus for reasons having nothing to do with legitimation, but that, in sticking with Malthus, Darwin happened to produce a legitimating theory. The other is that Darwin stuck with Malthus precisely *because* a Malthusian theory would be legitimating. Young equivocates between these two possibilities. So do Young's historiographic successors, Adrian Desmond and James Moore, in their biography of Darwin. In a representative passage, Desmond and Moore set the scene in 1842, when Darwin's Malthusian theorising was well developed: 'And with Chartists massing, it was time for middle-class Malthusians to stand up and show that nature was on the side of the bosses.'[55]

Does the equivocation matter? It does if we are after an explanation of why Darwin's theorising stabilised as it did. Suppose Darwin just happened to stick with Malthus at a time when middle-class Malthusians were keen to show the poor and powerless that a law of nature had ordained their position in the social hierarchy. In this case, there would be no explanation for the stability of Malthusian doctrine in Darwin's theorising on species. There would simply be

a remarkable coincidence between what was happening in Darwin's notebooks and what was happening outside his window. I doubt that this is how Young or Desmond and Moore want to be read. Theirs are fighting words. Claims about coincidence do not raise the temperature of debate. Claims about explanation do.

Suppose their claim is indeed the explanatory one, that Darwin stuck with Malthus because his society needed a theory that legitimated competitive social struggle by naturalising it.[56] There are honourable reasons for interpreting Darwin's theorising along these lines. Almost from the outset, Darwinians have enjoyed tremendous cultural authority. Their science is so much a part of the established order that Darwin's portrait now adorns the British ten-pound note. So much authority lends itself to abuse. Directing attention to an ideological function for the theory of natural selection is one strategy for countering uncritical deference.[57] Moreover, as we have seen, some of the natural-theological writers who shaped Darwin's concept of adaptation did write with propagandist intent. Signs are good that, if Ray or Paley had been asked why they wrote about the divine design of animals, they would have said something about the need to forestall revolution. But there is no serious suggestion that Darwin, had he been asked, would have said that he stuck with Malthus to forestall revolution.[58] Rather, the claim must be that Darwin was not aware of the legitimating needs to which the stability of Malthusian doctrine in his theorising was a response.

There are at least three clusters of difficulties with a legitimation explanation so construed. First, there are historical difficulties. The closer we look at the Victorian scene, the harder it becomes to maintain the tidy generalisations on which the explanation depends. Consider that equation: Malthusian=middle-class=Darwin=bosses. Yes, Malthus had supported the middle-class cause of Poor Law reform. But he had opposed that other middle-class cause, reform of the Corn Laws. Those laws protected the domestic grain market from foreign competition. In opposing their reform, Malthus sided with the interests of aristocratic and gentlemanly landowners against middle-class factory bosses (who wanted grain costs to fall so that workers' wages could fall in consequence).[59] Indeed, for all the growth in industrialisation, the dominant elite in England in the 1830s were the land owners. The Darwin family's wealth came more from land and other property than from manufacture.[60] So Darwin's sticking with

Malthus was not straightforwardly in the interests of the Chartist-threatened factory bosses.

Second, there are evidential difficulties. A number of apparently relevant sorts of facts turn out, on inspection, to be irrelevant to evaluating the legitimation explanation's truth or falsehood. It is irrelevant, for example, whether the poor and powerless in fact became complacent upon encountering Darwin's Malthusian theory. Rather, if the theory pacified the poor, then it successfully fulfilled its function; and if not – as appears to be the case – then it simply failed to function properly.[61] It is likewise irrelevant what Darwin himself thought he was doing in sticking with Malthus. On the legitimation explanation, whatever Darwin's conscious motives in keeping with a Malthusian theory, it was at an unconscious level that he responded to the need for such a theory. If unconscious motives do not announce themselves in the documentary record, then, it seems, so much the worse for the documents, and the desire for explanations that draw upon them.

Third, there are ontological difficulties. If we accept the legitimation explanation, we accept a holistic ontology for social life, with collective needs that are unconsciously harboured, unconsciously communicated and unconsciously acted upon, by mechanisms wholly mysterious.[62] In one sense, to indicate this is merely to flag the point that, at present, there is an ontological job of work to do. But that would be disingenuous. There is a long tradition of Anglophone flinching from holism in social explanation. Indeed, it might well be – or so those who back the legitimation explanation could argue – that squeamishness about collective needs and unconscious lines of action is itself evidence of the legitimating power of Darwin's theory. Maybe people bred to Darwinian thinking, with its emphasis on the individual, ever after regard individualist explanations as sensible and holistic explanations as suspicious. The social function of the theory of natural selection may thereby have become invulnerable to exposure, for wherever the theory goes, it takes an obfuscating prejudice about ontology along with it.[63]

VI THE *VERA CAUSA* IDEAL AND THE SOCIAL USES OF MALTHUS

What are the alternatives? It is no explanation to say that Darwin's theorising settled on a Malthusian theory because, when he

developed that theory, he hit upon the truth. If the independence thesis requires this view of Darwin's sticking with Malthus, then that thesis is a non-starter. People cannot be said to accept a theory *because* it is true. They may accept it because they believe the evidence shows the theory to be true, or because the theory is more parsimonious than its rivals, or because it fits well with prior beliefs and attitudes. They may accept it because those in authority have pronounced the theory 'true'. In the case of Darwin and Malthus, some combination of the above, properly understood, indeed constitutes a more satisfying version of the inseparability thesis than the Marxian one, or so I argue below. But the truth of a theory, any theory, has no power to explain why this or that individual or community accepts the theory.[64]

There is another reason, specific to the history of evolutionary biology, for dismissing the truth of the Malthusian theory of natural selection as explanatory. Since the synthesis of Darwinism and Mendelian genetics in the 1930s and 1940s, Darwinians have not regarded the struggle for existence as a cause of natural selection. As they now understand the theory, selection occurs whether or not resources are scarce. All that matters is that there are differences of fitness within a population. Commenting on the previously central role of Malthusian population pressure, Ronald Fisher, a preeminent synthetic theorist, wrote in 1930 that there was 'something like a relic of creationist philosophy in arguing from the observation, let us say, that a cod spawns a million eggs, that *therefore* its offspring are subject to Natural Selection . . .'[65] With the passing of Victorian society, struggle passed out of the foundation of Darwin's theory.

So Darwin cannot have stuck with Malthus because the Malthusian theory was the true theory. Nor can any other scientific seeker after truth, in whatever social context, have settled on a Malthusian theory because it was true. To explain the stability of struggle in Darwin's theorising, we need to look to a local and, quite probably, unique context. On this issue, the inseparability thesis appears to be the winner. But, as we have seen, the Marxian version of the thesis wins at high cost, demanding permanently blurred historical vision, cavalier disregard of Darwin's likely self-description and baroque ontological commitments.

A more attractive version of the thesis is now emerging. It centres on the principle that guided Darwin's reasoning, the *vera causa*

ideal.[66] We have already seen how local was that ideal.[67] What we have not noticed thus far are its cultural politics. When Lyell published his three volumes of *vera causa* geology in the 1830s, the character of the sciences in Britain was beginning to change in a fundamental way. At that time, Anglican clerics alone held the small number of scientific posts at the two ancient universities, Oxford and Cambridge, that dominated the elite life of the nation.[68] Church, state and science thus enjoyed strong institutional links. However, thanks especially to Scottish dissatisfactions and to movements within the Whig party – now reaching out to groups in dissent from Anglican doctrine – those links were coming to be increasingly contested. In the late 1820s, when the self-consciously Scottish Lyell began to write his *Principles of Geology*, his sympathies were becoming ever more Whiggish; and he saw his books as an attempt to expunge biblical religion from geology.[69]

Geology in particular had attracted the devout. Lyell's first teacher in geology, the Oxford cleric William Buckland, had claimed to find evidence of the flood that bore Noah's ark. In Buckland's view, this flood was but the most recent in a series of catastrophes that God had visited upon the Earth in preparation for the arrival of humans. Where Buckland offered narratives that arguably harmonised with Scripture, Lyell – following a long tradition of Scottish liberals in his hostility to Tory, Anglican, Oxonian alliances – eschewed such narratives as altogether unscientific. According to Lyell, a scientific, *vera causa* geology did not admit the existence of catastrophes, the likes of which had never been observed. Lyell's reforms struck at the English elite and their complacencies. If the reforms succeeded, the views of the cleric-geologists would cease to count as scientific explanations. Just as important, the cleric-geologists, beholden to the Church of England for their livelihoods, would cease to count as men of science.[70]

Recall that Darwin, a disciple of Lyell, was searching for a *vera causa* theory of species origins. In the months following his reading of Malthus, Darwin believed he had found the beginnings of an even better version of the *vera causa* theory he already had. His theorising stabilised around a Malthusian core in part because he had read Malthus' *Essay* in the autumn of 1838, and in part because, in Darwin's estimation, the Malthusian theory he developed thereafter conformed more closely than any of his previous theories to the *vera causa* ideal. With the cultural setting of that ideal now in view, the

two parts of this explanation can each be tied to the Whig reform drive, in and out of the sciences.

Let us take the reading of Malthus first. Commenting in his *Principles* on competitive struggle as the true cause of species extinction, Lyell had quoted, not Malthus, but the Swiss botanist Augustin de Candolle: 'All the plants of a given country are at war with one another.'[71] Lyell had made no reference to Malthus' *Essay* at all. At a moment of unrest over the Poor Law, however, Darwin – eager to resolve the conflict between his own observations and Lyell's theory of extinction – found a resolution in the writings of Malthus. The effect was to initiate that series of modifications in Darwin's thinking which, over the next months, would develop into the theory of natural selection. To the extent that Darwin's position among the Whig chattering classes predisposed him to associate Malthus with the idea of intense, competitive, providential struggle, Darwin's Whig affiliations thus help explain why he read Malthus' *Essay* when he did. As for Darwin's espousal of the *vera causa* ideal in the first place, it was not so much Darwin's as Lyell's Whig affiliations that matter. As we have seen, Lyell had advocated the ideal as part of the Whig drive to reform British institutions. When the Lyellian Darwin conformed his theorising on species to the *vera causa* ideal, he thus aligned his theories with Whig ambitions for British science and society generally.

The history of changing views on method can often seem remote from the social history of the sciences. When it comes to explaining the stability of struggle in Darwin's theorising, however, an attempt to integrate these histories offers several advantages. First, doing so enables us to explain Darwin's Malthusianism without explaining it away.[72] There is no denying or trivialising of the social uses of Malthus in Darwin's time and place. On the contrary, we see how crucial was Darwin's proximity to the Whig conversation about Malthus. Second, there is no need to ignore what Darwin thought he was doing. Darwin's self-conscious motives and allegiances are the starting point for the social-*vera causa* explanation. Third, we are saved from postulating obscure mechanisms of unconscious response to social needs. The explanation points towards mediated causal sequences, complicated but intelligible, leading from Darwin's Malthusian culture to the stable Malthusianism of his science. The upshot is a new option: inseparability without Engels.

VII DARWINIAN CONCLUSIONS

The question posed in this chapter about the independence of the theory of natural selection from its history can be posed of any successful scientific theory. It is nevertheless fitting that Darwin's theory in particular should come under scrutiny. As Philip Kitcher points out, the Darwinian view of life belongs to an era that saw the burgeoning of historical thinking across intellectual culture. Where history had previously been little noticed – in the composing of the Bible, in the heavens, in the structure of organisms – educated people began to see signs of historical process.[73] To look for those signs in the theory of natural selection itself is thus to take the historicist attitude home again.

Another consideration is that the independence and inseparability theses resemble, in a rough and ready way, divergent interpretations of the Darwinian history of life, now much debated. On the 'independence' side, there are arguments that life was constrained to evolve much as it has, that the trajectory of life was fairly robust in the face of contingent history. Even if much in the past had been otherwise, organisms would still have evolved eyes, wings and other familiar features. These are simply the best solutions to certain problems of survival on our planet. Natural selection has converged on them time and again, and would probably have done so however different the past. On the 'inseparability' side, there are arguments that the actual history of life was shaped fundamentally by contingent events, that it all – we all – could have turned out quite differently. An asteroid collision here rather than there, at this time rather than that, and the earth might now support radically different forms of life. Life as we know it is inseparable from the accidents that mark its history.[74]

The match between the inseparability thesis in the history of science and this contingentist thesis in evolutionary biology is no coincidence. One of the books that set historians of science posing sceptical, counterfactual, contextual questions about past scientific theories in the first place was Thomas Kuhn's *The Structure of Scientific Revolutions* (1962). In his conclusion, Kuhn famously urged readers to view the advance of scientific knowledge much as Darwin had viewed the advance of biological form. The message Kuhn drew from Darwin was contingentist. On Kuhn's account, the theory of natural selection made it possible to understand how

life could evolve, diversify and complexify without there being a goal to evolve towards – and this was what most deeply unsettled Darwin's contemporaries. In similar fashion, Kuhn argued, historians could now write the history of science without supposing that there was a final goal towards which scientific knowledge was progressing. In science as in life, wrote Kuhn, the process was one of 'evolution *from* primitive beginnings', not 'evolution *toward* anything'.[75]

Those who view Darwin's theory as inseparable from its historical matrix will find it easy enough to develop the parallel between Darwin's theory and an inseparability thesis about the theory. The theory of natural selection, they will say, revealed species as contingent entities, born of chance variation and conditions of life that happened to prevail at a particular time and place. Likewise, outside his specific historical matrix, Darwin might well not have made his particular assumptions, or resolved a crucial conflict between theory and observation as he did. It is even possible to imagine alternative successful biologies which do not include the theory at all. Next take the matter of kinds. Darwin's theory revealed species to be non-natural kinds, invented not by God but by taxonomists. Now historians have thrown doubt on the naturalness of the Darwinian kind 'adaptation'. There is nothing in nature that requires us to conceive plants and animals as mosaics of mechanical contrivances. Darwin inherited that conception from a peculiarly British tradition. Finally, there are explanations of stability. To the extent that species appeared stable, Darwin's theory attributed that stability not to some inner coherence, but to the surrounding conditions of life. In a broadly similar move, historians have emphasised explanatory connections between the stability of Malthusian struggle in Darwin's theorising and the surrounding social context, in particular the Whig reform drive.

Is it really more in the Darwinian spirit to hold that Darwin's own theory is a contingent product of social history, rather than a timeless truth? Before they accept this surprising claim, those who favour the independence thesis will rightly ask for more. They will query the notion of a 'successful' biology, and ask to see in detail how a creationist or saltationist biology, say, could be such a thing.[76] They will cast doubt on whether Darwin and Wallace's co-discovery of the theory of natural selection – so patent an example of theorists

converging independently on the truth – can be otherwise explained. They will rebuke as fallacious the inference that *because* the kind 'adaptation' emerged in one culture alone, *therefore* the kind is not natural. They will insist that Darwin's *vera causa* ideal, though local in certain respects, engendered a respect for empirical support that is common to all viable methodological ideals; and it was this respect that made Darwin stick with Malthusian struggle once he happened upon it. Making up our minds over the independence or inseparability of Darwin's theory from its history thus requires us at the same time to make up our minds about Darwin's intellectual legacies. We need to decide not only how best to honour them, but, indeed, what they are.

NOTES

Earlier versions of this chapter were presented in Cambridge, Leeds, York and St Louis in 1999 and 2000. I am grateful for the comments I received on those occasions, and, for detailed criticism of more recent versions, to Jon Hodge, Thomas Dixon, Lindsay Gledhill and John Christie.

1. K. Marx to F. Engels, 18 June 1862, quoted in Schmidt 1971, 46.
2. Hacking 1999, esp. ch. 3, provides the best overview of these debates. For a summary, see Radick 2002. The analysis of this chapter owes a great deal to Hacking's arguments and example. On the 'constructivist' or 'contextualist' turn among historians of science, see Golinski 1998 and Lightman 1997, Introduction. For another assessment in relation to Darwinian biology, see Ruse 1999b, discussed in Radick 2003.
3. On the history of such talk, see Schaffer 1990.
4. Inevitable, that is, so far as the scientific enterprise as we know it remained a going concern. See Hacking 2000.
5. One item on Marx's 1862 list that I shall not discuss here is the idea that competition in nature results in an increasing division of labour. For discussion, see, e.g., Ospovat 1981, chs. 7–9; Limoges 1994; Tammone 1995; Ruse 1999b, 241–5; Hodge, this volume; and the Introduction to this volume.
6. C. Darwin 1958, 140.
7. On the nature of Darwin's intelligence, see Gould 2000. Darwin himself glossed 'genius' rather un-Romantically, as above all 'unflinching, undaunted perseverance'; see Darwin [1871] 1981, 2, 328. For Darwin's own most famous eureka story, concerning the principle of divergence, see Darwin 1958, 120–1.

8. An old but still useful 'big picture' view of how capitalism begat Darwinism is Sandow 1938. On the social and economic history of Britain in this period, see Daunton 1995.
9. See Hodge, this volume.
10. On the run-up to the *Beagle* voyage, see Browne 1995, ch. 6. On the imperial context and content of Darwin's theorising, see Hodge, this volume.
11. McDonald 1998 is a novel about 'Mr Darwin's Shooter'. Covington's *Beagle* journal is currently available on the web. See Covington 1995.
12. For a study of authority, classification and museums in nineteenth-century natural history, see Barton 2000. On museums in science generally, see Pyenson and Sheets-Pyenson 1999, ch. 5.
13. On Darwin and the breeders, see Secord 1981, 1985. For general background on animal breeding in Victorian Britain, see Ritvo 1987.
14. Malthus 1826. Darwin read the sixth edition. The first, quite different edition was published in 1798. On Malthus, see Winch 1987.
15. C. Darwin 1958, 120.
16. Desmond and Moore 1991, 153–4, 196–7, 201, 216–18, 264–7. For a scathing indictment of 'Malthus' Law of Population and the New Poor Law framed in accordance with it', see Engels [1845] 1987, 281.
17. For an attempt to use computer modelling to settle similar issues about the history of quantum physics, see Pessoa 2001.
18. For discussion of this point, see the fourth section below.
19. See Hull, this volume, and Hodge 2000.
20. On pre-Darwinian theories of life's history and diversity, see Bowler 1989. On the 'singularity of Lyell', see Bartholomew 1979.
21. See Hodge, this volume, and Hodge and Kohn 1985.
22. Wallace's paper, 'On the Tendency of Varieties to Depart Indefinitely from the Original Type', was read at the Linnaean Society in London on 1 July 1858, jointly with a paper by Darwin and an excerpt from one of Darwin's letters. All are reprinted in Darwin and Wallace 1958. Two recent anthologies of Wallace's writings are Camerini 2001 and Berry 2002. A recent biography of Wallace is Raby 2001.
23. Kottler 1985.
24. Hodge 1991b, esp. 191–300. See also Beddall 1968 and, on the imperial context of Darwin's and Wallace's biogeographical views, J. R. Moore 2005.
25. J. R. Moore 1997. For Wallace on natural selection and political economy generally, see Coleman 2001. It has been alleged that Darwin was indebted to Wallace for the principle of divergence (see, e.g., Brooks 1984, esp. ch. 11, epilogue). The most careful discussions of the issues are Kohn 1981 and Beddall 1988. Neither finds the allegation

persuasive. On Darwin's independent development of the principle – the most important addition to the theory of natural selection following its formulation in the late 1830s – see Ospovat 1981, chs. 7–8 and Kohn 1985b.

26. For Darwin on 'species', see Beatty 1985, Hodge 1986, Stamos 1996, Stamos 1999 and McOuat 2001. See also the chapter by Hodge and Radick, this volume.
27. Talk of 'natural kinds' dates from the Victorian era. See Hacking 1991, 111–12.
28. C. Darwin [1859] 1964, 3.
29. C. Darwin [1859] 1964, 188–9. A famous passage from Darwin's book on orchids also bears quotation: 'if a man were to make a machine for some special purpose, but were to use old wheels, springs, and pulleys, only slightly altered, the whole machine, with all its parts, might be said to be specially contrived for that purpose. Thus throughout nature almost every part of each living being has probably served, in a slightly modified condition, for diverse purposes, and has acted in the living machinery of many ancient and distinct specific forms.' Darwin 1862, 348.
30. The most complete history of the concept to date is Amundson 1996, though it pays scant attention to contextual issues.
31. What of France? Darwin learned from Lamarck and Cuvier, both of whom dealt with adaptations. As Toby Appel has argued, however, the French naturalists of the late eighteenth and early nineteenth centuries 'had none of the British obsession with contrivance', perhaps because machines were less conspicuous in French economic life (Appel 1987, 57).
32. Boyle 1688, section 11; Ray 1692; Gillespie 1987. Excellent introductions to the historical literature on natural theology are Brooke 1991, ch. 6 and Brooke and Cantor 1998, ch. 5.
33. Boyle 1688, 47, spelling and italics in original; discussed in Gould 1998, 13. On the Strasburg clock and Boylean natural philosophy, see Shapin 1996, 32–7. On the cultural history of clock imagery, see O. Mayr 1986.
34. On the development of British natural theology between Boyle and Paley, see Brooke 1974.
35. On the British lead in horology in the eighteenth century and its social and economic consequences, see Landes 1983, ch. 14; Schaffer 1996.
36. Turner 1993, ch. 4, esp. 101–9.
37. Gillespie 1987.
38. Gillespie 1990, esp. 225–6.
39. Paley 1819, ch. 1.

40. On the influence of Paley on Darwin, see Brooke, this volume. On Paleyan Cambridge in Darwin's student days, see Fyfe 1997.
41. Paley 1819, 23–39.
42. C. Darwin [1859] 1964, 83–4; Boyle 1688, 43. Richards, this volume, argues for a Humboldtian rather than a Boylean–Paleyan genealogy here. On continuities and discontinuities between Boyle's *Disquisition* and Darwin's *Origin*, see Gould 1998.
43. Cf. Ospovat 1981, 35–7. On Darwin on adaptation, see Amundson 1996, 27–32. On the modern-day Darwinian concept of adaptation, see Sober, this volume.
44. Among the sceptics about the Darwinian concept of adaptation, see esp. Depew and Weber 1995, who argue that, contrary to the British tradition from Boyle to Dawkins, 'there is no watchmaker, blind or sighted, for the simple reason that there is no watch. Natural organization is not an artifact, or anything like it, but instead a manifestation of the action of energy flows in informed systems poised between order and chaos' (477–8).
45. Todes 1989, chs. 1–2.
46. C. Darwin [1859] 1964, 63.
47. Here I shall not address the separate problem of how to explain the stability of Darwinian theory within the biological sciences. My primary concern is with Darwin's own theorising, not with the public reception of his theory.
48. The Darwin–Malthus relationship has been much examined. For a survey of the literature up to the mid-1980s, see La Vergata 1985, 953–8. Notable among more recent efforts are Gordon 1989 and Benton 1995.
49. See esp. Marx's preface to *A Contribution to the Critique of Political Economy* (Marx [1859] 1959). One of the most influential philosophical discussions is Cohen 1978.
50. See the papers collected in Bukharin [1931] 1971.
51. On Marx's ambivalence towards Darwin's theory of natural selection, see Weikart 1998b, ch. 1.
52. F. Engels to P. L. Lavrov, 12–17 November 1875, quoted in Schmidt 1971, 47.
53. Young 1985a, 240. Young explicitly allied himself with the interpretative tradition of Marx and Engels. See, respectively, Young 1985a, 239 and Young 1985b, 631–2.
54. My analysis here is indebted to the example of Rosen 1996, esp. 52, 184–200.
55. Desmond and Moore 1991, 294. On the Desmond–Moore map of the Victorian transmutation debates, Tories backed special creation (no natural/social change), Whigs backed natural selection (lawful, slow, grad-

ual natural/social change) and radical revolutionaries backed Lamarckism (rapid, up-from-below natural/social change). Desmond develops the Lamarckian-radical connection in Desmond 1989. For alternative maps, see Rupke 1994 and Secord 2000.

56. Muñoz-Rubio 1999 is in much the same vein.
57. Hilary Rose, for example, adduces the Darwin–Malthus connection as part of a critique of evolutionary psychology (H. Rose 2000, esp. 107–10). For similar attacks on the older sociobiology, see Lewontin 1993, ch. 1, esp. 9–10; Sahlins 1976, xv, ch. 4.
58. Asking Darwin why he stuck with a Malthusian theory is, of course, not the same as asking him whether, in the light of his Malthusian theory, competitive struggle is a social good. See Paul, this volume, for Darwin's affirmative response to the latter question.
59. Winch 1987, esp. ch. 5.
60. Hodge 1994 and this volume.
61. The miner Chester Armstrong read Darwin en route to reading Marxist economics. See J. Rose 2001, 74.
62. Rosen 1996, 197.
63. Roughly the same difficulties attach to the legitimation explanation of Darwin's public claims that natural selection is progressive (as in Gould 1996, ch. 12). For a critique, and an attempt to supply a better explanation, see Radick 2000. On the general history of theorising about evolutionary progress, see Ruse 1996.
64. Hacking 1992, 14; 1999, 81–2, 232 (note 13).
65. Fisher 1930, 43–4, quote on 43, italics in original. For discussion, see Depew and Weber 1995, 269 and Gayon, this volume.
66. What follows is a modified version of the argument in Depew and Weber 1995, esp. chs. 3 and 5. For discussion, see Radick 1998, 353–5.
67. For the history of the ideal from Newton to Darwin, see Kavaloski 1974. See also L. Laudan 1981, ch. 7.
68. Turner 1978.
69. Secord 1997.
70. On scriptural geology and its opponents, see Gillispie [1951] 1996. Rupke 1996 helpfully summarises later historical work on this topic. On Lyell's *vera causa* geology, see R. Laudan 1982.
71. Lyell [1830–3] 1990, II, 131.
72. Cf. the strictures in Shapin 1982, 178; Shapin and Barnes 1979.
73. Kitcher, this volume.
74. For the convergentist case, see Conway Morris 1998; for the contingentist case, see Gould 1989. For an overview, see Sterelny and Griffiths 1999, ch. 12. On the theological dimensions of this debate, see Ruse, this volume.

75. Kuhn 1970, ch. 13, esp. 170–3, quote on 170–1, italics in original. For Kuhn as inspiration for theory–history inseparability theses, see Hacking 1999, 96–9. So far as Kuhn's book influenced Stephen Jay Gould, the most prominent contingentist, it may be that Kuhn lies behind the evolutionary-biological side of the symmetry as well as the history-of-science side. See Gould 2002, 967, and, for a distinct echo of Kuhn on evolution-away-not-towards, Gould 1996, 173.
76. For an attempt to make sense of 'success', see Hacking 1999, 69–70,74–8. On saltationist tendencies in the history of evolutionary biology, see Schwartz 1999 and Gould 2002, ch. 5. On the successful biology that might have been if not for Darwin, see Bowler 2008.