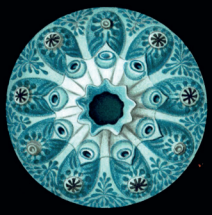
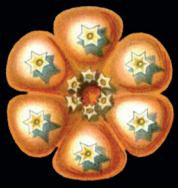
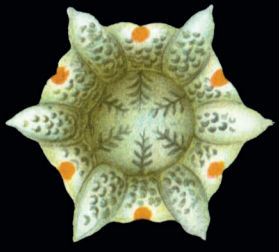




Cambridge Elements

The Philosophy of Biology


The Darwinian Revolution




Michael Ruse



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THE DARWINIAN REVOLUTION

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The Darwinian Revolution

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Abstract: What is the Darwinian Revolution and why is it important for philosophers? These are the questions tackled in this Element. In four sections, the topics covered are the story of the revolution, the question of whether it really was a revolution, the nature of the revolution, and the implications for philosophy, both epistemology and ethics.

Keywords: philosophy of science

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Prologue

In 1961, the well-known American philosopher Ernest Nagel published *The Structure of Science: Problems in the Logic of Scientific Explanation*. It is an impressive work, laying out the so-called "logical empiricist" philosophy of science. This is a physics-based vision of science that goes back centuries. The great British philosophers of science, John F. W. Herschel (1830) and William Whewell (1840), writing in the first half of the nineteenth century and ardent Newtonians both, would have found much that is familiar. Nagel, along with others – notably Richard Braithwaite (1953) in England and Carl Hempel (1965, 1966) in America – saw theories as axiom systems. There are hypotheses at the top – Newton's laws of motion and of gravity – and, deduced further down, empirical laws – those of Kepler and Galileo. The discussion was sophisticated and there was a huge amount of detail, ranging from general theoretical problems like the use of analogy through to problems of confirmation, especially where unseen or theoretical entities are concerned.

It would not be true to say there is nothing historical in Nagel's book. Apart from a discussion of history as a science, or perhaps as a failure as a science, there is a very good chapter on theory reduction. This occurs when an older theory like thermodynamics (to use Nagel's example) is overtaken and absorbed by a new theory, in this case statistical mechanics. Empirical laws about the temperature and pressure of gases are explained in terms of little balls buzzing around in a container. Underlying everything, though, lay the logical empiricist mantra – separate the context of discovery from the context of justification. Discovery, found in the *gemütlich* homes of the historians, deals with fallible people having all sorts of irrational thoughts through time. Hempel's (1966) example was of Kekulé dozing off to sleep in front of a fire, dreaming of a snake swallowing its tail, and thus discovering the circular nature of the benzene molecule. Justification, done in the Spartan quarters of the philosopher kings, deals with entities and their connections in the unchanging Platonic world of the Forms. Anything Newtonian qualifies here. History and theory change are not big items. There is, for instance, no reference to "revolution" in the index of Nagel's book. There was no discussion of geology, for all that, with the coming of continental drift and plate tectonics; the earth sciences were at that time in the middle of the greatest upheaval of their history. Here there was a break with the past. Whewell (1837) was always interested in the history of science and he and Herschel were major players in the geological theorizing of their day. No longer. Logical empiricism was ahistorical. And proud of it![1]

[1] In 1978, at a meeting of the Philosophy of Science Association, I was part of a panel discussing the revolution in geology (Ruse 1981). I happily hammered away at Nagel and Hempel until,

Next year, 1962, everything changed. A man outside the philosophical community – an erstwhile physicist converted into a historian of science – published a book with a self-referential title. *The Structure of Scientific Revolutions* by Thomas Kuhn, already the author of what is still the standard account of the Copernican Revolution, challenged conventional philosophical thinking on the nature and direction of science. On his first page, Kuhn threw down the gauntlet.

> History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed. That image has previously been drawn, even by scientists themselves, mainly from the study of finished scientific achievements as these are recorded in the classics and, more recently, in the textbooks from which each new scientific generation learns to practice its trade. Inevitably, however, the aim of such books is persuasive and pedagogic; a concept of science drawn from them is no more likely to fit the enterprise that produced them than an image of a national culture drawn from a tourist brochure or a language text. This essay attempts to show that we have been misled by them in fundamental ways. Its aim is a sketch of the quite different concept of science that can emerge from the historical record of the research activity itself. (Kuhn 1962, 1)

Overnight, everyone in the philosophy of science community rushed into revolution studies, usually with the intention of showing that brash outsider Thomas Kuhn simply had no idea of what he spoke (Shapere 1964). The most notable and persistent critics were the Austro-British philosopher Karl Popper and his acolytes (Lakatos and Musgrave 1970). In a way, this was all a bit like banning a book. It only drew attention to *Structure* and made everyone want to read it. Fifty years later, I remember still the thrill as Kuhn's vision of science smashed through all one had hitherto considered unassailable. It was like a Godzilla movie! Next up, the naturalistic fallacy.

Contingently, by the mid-1960s, something else was happening. Probably because biology itself was now about to enter golden years – there had been the double helix discovery at the beginning of the 1950s and there were provocative new models of social behavior by the beginning of the 1960s – the area started to attract the attention of philosophers of science. My *The Philosophy of Biology* (1973) and David Hull's *The Philosophy of Biological Science* (1974) were not in themselves great books, but they did define the field and announce that

through the vile hangover that was customary on these occasions, I realized that sitting in the front row, smiling broadly and nodding in agreement, were none other than Ernest Nagel and Carl Hempel. I have always taken this as a message to have a good laugh at or with bumptious youngsters who attack my work – as well as a warning to drink rather less the night before I am going to perform.

there were exciting problems worthy of informed analysis. Above all, as professionally trained philosophers of science, we knew that if one was serious one had to know something of the science itself. Too often biology had been taken as something different – a "narrative science" or some such thing – and too often, "different" was equated with "second-rate." We Young Turks – Hull and I were the introductory text writers for a group – showed that if you turn from reading only popular books on the fossils and look at what real biologists do – genetics – a different, although more familiar (to the logical empiricists), type of picture emerges. Perhaps biology is not so very different (meaning second-rate) from the physical sciences.

For the understanding of Charles Darwin and the revolution associated with his name, it was rather like the alignment of the suns at the climax of the *Dark Crystal*. Studies of Darwin and of the theory of evolution that he produced had, for at least a hundred years, been the demesne of relatives or students or enthusiasts or just plain moneymakers. Many an aged biologist had used his retirement years to sing the praises of his hero, the modest English naturalist, author of *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. Then, in the 1950s, the history of science was professionalized – Harvard was a center and Kuhn an early beneficiary. Archives were opened up, scholars were given professional training as historians, and the quality of scholarship leapt in bounds. Attention turned to Charles Darwin, the sources on which he drew, the work that he did, the influences that he had. His legacy today. In short, people turned to the Darwinian Revolution – that change of worldview wrought by Darwin, taking us from the miraculous instantaneous creation of animals and plants, to a natural world of evolutionary change, to an ever-unfurling tree of life, from the monad to the man.

It was as if preordained by the God of the Calvinists that pioneering philosophers of biology like Hull and I would get involved. We were already working seriously on the nature of contemporary evolutionary biology. What more natural than to extend our gaze back to Darwin and his era and to extend our analyses, not merely seeing if Darwin's work as it stood fit expected patterns, but also if the Revolution was truly as Kuhn claimed it to be. Perhaps it was something different – possibly a reduction of the kind envisioned by Nagel? Hull (1973) put together a still-valuable collection of contemporary responses to the *Origin*, and I – having spent a sabbatical year in the Darwin archives at Cambridge retooling as a historian – wrote *The Darwinian Revolution: Science Red in Tooth and Claw* (1979), trying to complement my overview in the philosophy of biology with a like overview in the history of

biology.[2] Neither Hull nor I were convinced by Kuhn, but we stood foursquare with him against his analytical philosophical critics in thinking that the way to move forward is by understanding the history as well as if not better than the professional historians of science (Callebaut 1993).

Controversies grew and these continue to this day (Richards and Ruse 2008, 2016), especially in my home discipline. Put bluntly, in fashionable philosophical circles today, Darwinian theory – a jewel in the crown of science – has an appalling reputation. Templeton Prize winner Alvin Plantinga (1991) thinks the evidence for evolution "ambiguous and inconclusive." He opts for some form of biblical Creationism, thinking it "somewhat more probable with respect to the evidence" (687). Plantinga is a Calvinist, but nonbelievers go much the same way. Noted philosopher of mind Jerry Fodor cowrote a book with the title *What Darwin Got Wrong.* Lots and lots, apparently. Openly atheistic Thomas Nagel (1979) makes his position very clear: "Biology may tell us about perceptual and motivational starting points, but in its present state it has little bearing on the thinking process by which these starting points are transcended" (146). Nagel doesn't just reject the philosophical relevance of Darwin's thinking. He rejects Darwin's thinking. Titles tell all. *Mind and Cosmos: Why the Materialist Neo-Darwinian Conception of Nature Is Almost Certainly False* (2012). He is empathetic to a form of Creationism-lite, Intelligent Design Theory.

I, to the contrary, am absolutely convinced that the Darwinian Revolution is the most important thing that ever happened to philosophy. As Thomas Henry Huxley joked, recognizing that we are modified monkeys, not modified mud, is the vital first step to a properly grounded theory of knowledge (epistemology) and theory of morality (ethics). I am certainly not going to show that in this little essay. It is but a first step. I am struck always in these discussions how, in their whole lives, neither Thomas Nagel nor any of the other naysayers seems to have opened a professional publication dealing with Darwinian themes. If we are going to start taking Darwin seriously, as I titled one of my early books, we need to know about Darwin's contributions and his legacy, and its importance. So, to start the job, I offer here a serious look at the Darwinian Revolution, in all its complexity and messiness. What did Charles Darwin do and why did it matter? In the first section that follows, I tell you something of the history of the Darwinian Revolution. In the next section, I ask about its status as a scientific

[2] I learnt a lesson never to be forgotten. Unaware that academics read only the first and last pages of books they are reviewing, naïvely I introduced my book as an "overview," expecting everyone to say: "No! No! Mike! It is a profound and deeply researched treatment of a difficult but rewarding topic." Ha! Ha! "Overview," I said, and "overview" it became. Just for the record, this book is "a profound and deeply researched treatment of a difficult but rewarding topic."

revolution. In the third section, l look at the episode philosophically. This is an Element on Charles Darwin, not Thomas Kuhn, but here it will be appropriate to use Kuhn's *Structure* as the entrée. In the fourth and final section, I take up issues arising in the philosophical realm, especially with respect to work to be done.

I offer signposts, not proofs. This is not the fourth *Critique*! I very much doubt that anyone – biologist, philosopher, or historian – will agree with everything I have to say. I hope they don't. That would be boring. I am now nearly a decade past my biblically allotted three score years and ten. The battle is still to be won. I hope this little essay will inspire others to take up what I must leave unfinished.[3]

1 What Was the Revolution?

Progress versus Providence

Something does not come from nothing. The idea of ongoing organic change, evolution, has roots, to use an apt metaphor, in the chain of being, something with a long history, at least back to Aristotle. All organisms can be put on a ladder, from the simplest to the most complex, from the grub to the human (Lovejoy 1936; Ruse 1996). Often the ladder kept going, through the orders of angels up to God himself. In the early eighteenth century, with the fixed world order much more in question, there were some who started the chain moving. Rather than a ladder, they thought more in terms of a one-way escalator, with law-driven passage up the scale. Empirical evidence was scanty. Anatomy yields fascinating isomorphisms – what we now call "homologies" – between organisms. Evolution gives a ready explanatory answer. Shared ancestors. Fossil discoveries were also pointing this way a bit, although the record as such was nowhere near adequately uncovered to offer real insights or supports. Often analogies were drawn with individual development and, as often, primitive societies were highlighted. If we civilized humans can rise up from the savages, why not the higher primates from fish?

Truly though, this was not really a discussion about empirical questions. It was more a matter of underlying metaphysical world pictures. For Christians, traditionally, this is a world of Providence. It is a world where everything is done in the light of our Creator and where we realize that our efforts are essentially worthless. All depends on the grace of God. Isaac Watt's great hymn, written at the beginning of the eighteenth century, tells all.

[3] *The Encyclopedia of Darwin and Evolutionary Thought* (Ruse 2013a) offers much background to the issues discussed in this *Element*.

When I survey the wondrous cross
On which the Prince of glory died,
My richest gain I count but loss,
And pour contempt on all my pride.

Challenging this now, thanks particularly to the increasing power of science and technology, was the philosophy of Progress.[4] This is the complete reverse of Providence, for it argues that we ourselves can, through our thought and effort, make for lasting differences and improvement – in science, in education, in health care, and much more.

Evolutionary thinking about the world of animals and plants simply rode into being on the back of the metaphysic of Progress. Listen to Erasmus Darwin, grandfather of Charles, physician and friend of scientists and industrialists at the end of the eighteenth century. He expressed his ideas in verse.

Organic Life beneath the shoreless waves
Was born and nurs'd in Ocean's pearly caves;
First forms minute, unseen by spheric glass,
Move on the mud, or pierce the watery mass;
These, as successive generations bloom,
New *powers* acquire, and larger limbs assume;
Whence countless groups of vegetation spring,
And breathing realms of fin, and feet, and wing.

Thus the tall Oak, the giant of the wood,
Which bears Britannia's thunders on the flood;
The Whale, unmeasured monster of the main,
The lordly Lion, monarch of the plain,
The Eagle soaring in the realms of air,
Whose eye undazzled drinks the solar glare,
Imperious man, who rules the bestial crowd,
Of language, reason, and reflection proud,
With brow erect who scorns this earthy sod,
And styles himself the image of his God;
Arose from rudiments of form and sense,
An embryon point, or microscopic ens!

(Darwin 1803, 1, 11, 295–314)

Notions of biological progress, running up from the blob to the human, make the very backbone (to use another apt metaphor) of this vision, shown as Darwin explicitly tied his biology into his philosophy. The idea of organic progressive evolution "is analogous to the improving excellence observable in every part of

[4] When referring to the cultural notion, I shall capitalize – Progress – and when talking of the biological notion, I shall not – progress.

the creation; such as the progressive increase of the wisdom and happiness of its inhabitants" (Darwin 1801, 2, 247– 2).

Erasmus Darwin's ideas spread quickly. They were translated into German, shaking the aged Immanuel Kant, who was already much impressed by organic isomorphisms. Darwin didn't have much idea of causes, of mechanisms, although he clearly subscribed to some form of the inheritance of acquired characteristics. As it happens, for all that it is now named after him, that mechanism was never very central to the thinking of Darwin's contemporary, the French biologist Jean Baptiste de Lamarck – who was also now starting to think in an evolutionary mode. It was more an addition to Lamarck's main picture, which was that of primitive forms constantly being created – spontaneously generated – in pools, by lightning and the like, and then proceeding up the chain of being. For Lamarck, the main cause of change was an occult-like, nonmaterial force – *le pouvoir de la vie* – progressively powering organisms ever higher.

Lamarck published his *Philosophie Zoologique* in 1809. Although the author was respected as a systematist, most people did not buy into evolutionism, Lamarckian or otherwise. Given that there was not a great deal of empirical evidence either way, most of the concerns were about the threat to Christianity – Providence. One should not think however that the opponents of evolution were invariably motivated by religious worries of the kind that fuel today's American, anti-evolutionary, biblical literalism – Creationism. Increasingly, geology demanded great spans of time, and did not the bible say that a thousand years are as but a day in the eye of the Lord? Easy to stretch out those days of creation. As easy to argue that the Deluge was not universal, being confined to some limited area in the Middle East. What really worried people was the design-like nature of organisms, the adaptations – the hand and the eye, the root and the leaf. How could such complex functioning things come about by blind chance? There had to be an intelligence behind it all. Back this up with a thin fossil record and other choice items – the comparative anatomist Georges Cuvier (1813) argued that the forms of mummified Egyptian animals show there is no great change in time – and the case was complete (Rudwick 1972).

Those who were not convinced, who increasingly yearned for evolution, like the Scottish publisher Robert Chambers writing anonymously and publishing *The Vestiges of the Natural History of Creation* in 1844, generally had some (Progressivist) axe to grind. Chambers thought that, against the miracle stories of Genesis, natural origins are more in line with the industrialized society that Britain had by then become.

> A progression resembling development may be traced in human nature, both in the individual and in large groups of men . . . . Now all of this is in conformity with what we have seen of the progress of organic creation. It seems but the minute hand of a watch, of which the hour hand is the transition from species to species. Knowing what we do of that latter transition, the possibility of a decided and general retrogression of the highest species towards a meaner type is scarce admissible, but a forward movement seems anything but unlikely. (Chambers 1846, 401– 402)

Starting to soften some of the starker differences between Progress and Providence, even some religious got on this bandwagon. Anglican minister and professor, Baden Powell (1855), father of the founder of Scouting, wrote that just as the English show their superiority by inventing machines for weaving previously done by hand, so God shows his superiority by creating through machine, aka evolution, than by hand, aka miracles. Most significantly and influentially, that most Victorian of poets, Alfred Tennyson, incorporated evolutionary themes into *In Memoriam* (1850), his panegyric to his dead friend Arthur Hallam. Depressed by what he saw as the meaninglessness of existence, he found hope in the optimism of a Christianized form of evolutionism. Hallam's bad luck was to come before his time.

> A soul shall strike from out the vast
> And strike his being into bounds,
>
> And moved thro' life of lower phase,
> Result in man, be born and think,
> And act and love, a closer link
> Betwixt us and the crowning race
> . . . . . .
> Whereof the man, that with me trod
> This planet, was a noble type
> Appearing ere the times were ripe,
> That friend of mine who lives in God.

When *Vestiges* was published in the mid-1840s, there was massive opposition in some quarters, particularly those of professional science. William Whewell (1845) was strongly against it. He produced a little book of extracts from earlier writings, with a sterling new preface, in which he managed not to mention once the name of his vile target. Baden Powell and Tennyson show that the story is more complex (Secord 2000). *In Memoriam* was hugely popular, giving great comfort to many, including the queen when she was widowed. Even more important were the early writings of Herbert Spencer, the (future) author of the massive "Synthetic Philosophy," a comprehensive guide to the solution of every problem that has ever been posed by a human being. By the

mid-1850s, Spencer was well into proselytizing for Progress and evolution – which he took to be one and the same – an enthusiasm he kept up for the next half century (Richards 1987). As we turn now to Charles Darwin, realize that the winds may have been chilly, but the ground was fertilized and watered (Ruse 2008).

Charles Robert Darwin

Privately, even before *Vestiges* appeared, the grandson of Erasmus Darwin was at work (Browne 1995, 2002). Charles Darwin was born into a comfortable, upper-middle-class, English family. His father was a physician and his maternal grandfather was Josiah Wedgwood, the founder of the pottery works that bore his name. More of this family money came his way when Charles married his first cousin, Emma, also a grandchild of Josiah. After an attempt at medicine in Edinburgh, Darwin moved to Cambridge University, intending to become an Anglican clergyman. This intention faded when he was offered the post of ship's naturalist on board HMS *Beagle*, about to set off on a five-year (1833–36) voyage to South America and eventually all around the world. Darwin was hardly a fully qualified scientist when he joined up – apart from anything else he did not take a science degree because there were then no such degrees – but he was a quick learner and, before long, he had established his credentials and authority. Through his life, he never worked for pay because he could live on family money. No one ever doubted his status as a professional scientist.

Charles Darwin did not become an evolutionist on the *Beagle* voyage. This happened in the spring of 1837 when he asked an ornithologist to catalogue his avian specimens, especially those collected on a group of islands in the Pacific, the Galapagos archipelago, some five hundred miles from the coast of Ecuador. The birds were so similar and yet not quite identical. They were like the birds of the American mainland too, and not at all like the birds of Africa. There could only be one answer – what Darwin called "descent with modification." At once, Darwin was sketching the famous tree of life that still dominates evolutionary thinking. Journey over. Or was it? Why go any further? Why not stop there? Darwin knew the challenge. In *Critique of the Power of Judgment* (1790), Immanuel Kant had said there could never be a Newton of the blade of grass. There would never be the biological equivalent of the Newtonian force of gravitational attraction to explain the biological world as Newton explains the physical world. Darwin had to find that equivalent.

He worked frenetically for eighteen months and, in the closing days of September 1838, hit on the solution. At the end of the eighteenth century,

the Anglican clergyman Thomas Robert Malthus (1798, sixth edition 1826) had argued that population numbers will always outstrip available supplies of space and food. Hence, there will inevitably be a "struggle for existence." Darwin saw that, in nature, this could be the pressure behind what increasingly he saw as the key to organic change: the selection for the desirable as practiced in the farmyard, aiming for wool and beef and eggs and the like, and by animal and plant hobbyists, aiming for songsters and finery and the like. "Natural selection," or as it was to be called "the survival of the fittest," appeared on the scene.

In 1842, Darwin wrote up his ideas in a 35 page "Sketch" and then in 1844 in a 230 page "Essay" (Darwin and Wallace 1958). Then, he sat on his ideas. Darwin fell very sick – possibly undiagnosed lactose intolerance – and that made him cautious. More important would have been his standing in the scientific community. The reception of *Vestiges* showed that publishing an evolutionary tract would have been professional suicide. Whewell was one of Darwin's strongest mentors. Finally, in 1858 Darwin's hand was forced by the arrival of an essay from a young naturalist out east, Alfred Russel Wallace. The pages contained much the same ideas as those of Darwin. Dropping everything, Darwin raced to finish his book, and in the late fall of 1859 the *Origin* appeared.

The *Origin* is deceptive (Ruse 1979). It is written in a user-friendly manner, with helpful asides and analogies. At times, it reads like the fiction that Emma read aloud to Charles every afternoon, as he lay on a sofa and smoked a cigarette. Comfort food starting with no mathematics! It is deceptive. Darwin set out to convince the reader of something unseen – life's history leading up to the present. The surface of the text may be casual, the depths were deep and carefully explored and confirmed. The strategy is threefold. First, Darwin followed his own route to discovery, telling the reader all about the nature and success of animal and plant breeding, artificial selection. Here, Darwin was obeying the empiricist philosopher, John F. W. Herschel (Pence 2018). Crucially, Herschel argued that the best "true" causes – *verae causae* – are based on analogy, from the sensed to the supposed. Herschel's example was that, from the sense of force we feel when we spin a stone at the end of a piece of string around and around in a circle, we know a force acts to pull the circulating moon to earth and hence keep in orbit. The reader is primed for the analogy of natural selection working in nature.

Then, in a kind of protological empiricist fashion, Darwin followed Herschel and the more rationalistically inclined William Whewell in showing that, if only informally, we have a kind of deductive argument first to the conflict between organisms.

> A struggle for existence inevitably follows from the high rate at which all organic beings tend to increase. Every being, which during its natural lifetime produces several eggs or seeds, must suffer destruction during some period of its life, and during some season or occasional year, otherwise, on the principle of geometrical increase, its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are produced than can possibly survive, there must in every case be a struggle for existence, either one individual with another of the same species, or with the individuals of distinct species, or with the physical conditions of life. (Darwin 1859, 63–64)

Second, to natural selection.

> Let it be borne in mind how infinitely complex and close-fitting are the mutual relations of all organic beings to each other and to their physical conditions of life. Can it, then, be thought improbable, seeing that variations useful to man have undoubtedly occurred, that other variations useful in some way to each being in the great and complex battle of life, should sometimes occur in the course of thousands of generations? If such do occur, can we doubt (remembering that many more individuals are born than can possibly survive) that individuals having any advantage, however slight, over others, would have the best chance of surviving and of procreating their kind? On the other hand, we may feel sure that any variation in the least degree injurious would be rigidly destroyed. This preservation of favorable variations and the rejection of injurious variations, I call Natural Selection. (80–81)

Important for Darwin, making selection the biological equivalent of Newtonian gravitational attraction – it was Newton who first made the demand for *verae causae* – was that it does not just bring about change. It brings about adaptations, characteristics that seem as if designed for the well-being of their possessors. "How have all those exquisite adaptations of one part of the organisation to another part, and to the conditions of life, and of one distinct organic being to another being, been perfected? We see these beautiful co-adaptations most plainly in the woodpecker and missletoe; and only a little less plainly in the humblest parasite which clings to the hairs of a quadruped or feathers of a bird; in the structure of the beetle which dives through the water; in the plumed seed which is wafted by the gentlest breeze; in short, we see beautiful adaptations everywhere and in every part of the organic world." (60–61)

Reflecting the different interests of breeders – food and other needed things versus beauty and fierceness (as in fighting cocks) and other prized things – Darwin added a secondary mechanism of sexual selection (Richards 2013). Whereas natural selection involves food and other needed things,

sexual selection for mates involves beauty and fierceness and other prized things. Then, mechanisms introduced, Darwin added some complexifying factors, most particularly the division of labor (or "labour" as he writes it). It is this that lies at the heart of speciation. Organisms specialize in different ways and before long they have grown apart. It is all like the way that different parts of the individual body – heart, lungs, brain – do different things. "So in the general economy of any land, the more widely and perfectly the animals and plants are diversified for different habits of life, so will a greater number of individuals be capable of their supporting themselves. A set of animals, with their organisation but little diversified, could hardly compete with a set more perfectly diversified in structure." (116)

With his causal package in hand, Darwin felt able to explain the tree of life. "The affinities of all the beings of the same class have sometimes been represented by a great tree. I believe this simile largely speaks the truth." Continuing:

> As buds give rise by growth to fresh buds, and these, if vigorous, branch out and overtop on all sides many a feebler branch, so by generation I believe it has been with the great Tree of Life, which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever branching and beautiful ramifications. (130)

"Descent with modification," but truly "ascent with modification."

The final part of the *Origin*, over half the book, establishing a *vera causa* indirectly, conformed to what Whewell called a "consilience of inductions." When you are trying to prove the truth of an unseen claim – molecules or murderers – you work through circumstantial evidence, trying to find clues across the spectrum. You look for traces. You look for blood-stains. So worked Darwin. He ran the full gamut of the life sciences – behavior, especially social behavior, as in the hymenoptera (ants, bees, and wasps); paleontology, the fossil record; biogeography, the distribution of those organisms on the Galapagos archipelago; systematics, classification; anatomy, those homologies; embryology, ontogenetic development; and, finally, vestigial organs like the appendix. All explained by evolution through natural selection. All pointing to the truth of evolution through natural selection. In a way, a bit like a series of reductions, as envisioned by Ernest Nagel. Only in a way. Darwin was not actually deducing things like biogeographical distributions from natural selection. Rather using natural selection with other facts to explain such distributions – although, to be fair, sketching the direction in which a more formal treatment might be attempted.

Finally, the most famous passage in the history of science.

> It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us . . . Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved. (489–490)

In the *Origin*, Darwin said virtually nothing about our species, *Homo sapiens.* This was not because he thought evolution through selection does not apply to us. In his private notebooks that he kept while he was working through his ideas, the very first indication we have that Darwin has grasped selection is an application to humans, and not just to humans but to our intelligence. However, Darwin was always inclined to caution. Belief was one thing. Public belief was another. Darwin didn't want to detract from getting the basic theory before everyone, so he left matters with the most famous understatement of the Victorian era. "Light will be thrown on the origin of man and his history." (488) No one was fooled. At once, the story of the *Origin* was taken as the "monkey theory."

Had not Wallace become enamored with spiritualism and argued that human evolution could not have been produced by natural selection, Darwin may never have turned full time to humans. He was happier working on little problems that interested him, like the nature of orchids (Darwin 1862). Under threat, Darwin launched into another big book, and in 1871 published the *Descent of Man or Selection in Relation to Sex*. He argued that we evolved from primates no longer extant in Africa; we are therefore cousins to the higher apes, and we show much evidence of our evolution in our thought and behavior. Darwin paid attention to our belief in God and to our moral sense. As far as the former is concerned, he followed Hume – "human faces in the moon, armies in the clouds" – in thinking it all a big mistake.

> The tendency in savages to imagine that natural objects and agencies are animated by spiritual or living essences is perhaps illustrated by a little fact which I once noticed: my dog, a full-grown and very sensible animal, was lying on the lawn during a hot and still day; but at a little distance a slight

> breeze occasionally moved an open parasol, which would have been wholly disregarded by the dog, had any one stood near it. As it was, every time that the parasol slightly moved, the dog growled fiercely and barked. He must, I think, have reasoned to himself in a rapid and unconscious manner, that movement without any apparent cause indicated the presence of some strange living agent, and no stranger had a right to be on his territory. (Darwin 1871, 1, 67)

Morality Darwin took more seriously. He did not want to argue that we have no moral sense. Instead, he argued that cooperation, promoted by morality, is of great adaptive help in the struggle for existence. "There can be no doubt that a tribe including many members who, from possessing in a high degree the spirit of patriotism, fidelity, obedience, courage, and sympathy, were always ready to give aid to each other and to sacrifice themselves for the common good, would be victorious over most other tribes; and this would be natural selection." Comes the consequence. "At all times throughout the world tribes have supplanted other tribes; and as morality is one element in their success, the standard of morality and the number of well-endowed men will thus everywhere tend to rise and increase." (1, 166)

The *Descent of Man* is curiously out of balance. Over half is devoted to sexual selection, the secondary mechanism, introduced in the *Origin* but not much discussed. Organisms compete within the species for mates. This gives rise to organs of conflict like the antlers of the deer, and organs of attraction like the tail feathers of the peacock. The reason for the extended discussion of sexual selection is simple. Wallace (1870) argued that there are human features, like hairlessness, that can have no natural selective advantage. Hence, spirit forces must be involved. Darwin agreed that things like human hairlessness cannot be produced by natural selection; but he thought they could be produced by sexual selection. People choose mates who fit their definition of beauty and being ape-like is not one of them. This led happily to some very Victorian reflections.

> Man is more courageous, pugnacious, and energetic than woman, and has a more inventive genius. His brain is absolutely larger, but whether relatively to the larger size of his body, in comparison with that of woman, has not, I believe been fully ascertained. In woman the face is rounder; the jaws and the base of the skull smaller; the outlines of her body rounder, in parts more prominent; and her pelvis is broader than in man; but this latter character may perhaps be considered rather as a primary than a secondary sexual character. She comes to maturity at an earlier age than man. (Darwin 1871, 2, 316–317)

And so on and so forth at length.

Teleology

Let us look a little more at Darwin's theorizing, particularly in the *Origin*. I have pointed to the methodological influence of Herschel and Whewell. I have also suggested that Herschel and Whewell are forerunners to the logical empiricists. Although things are a lot looser than one might hope for in a fully developed and articulated theory, I conclude that Darwin's theory, in some important sense, measures up to the kind of theory praised and cherished by logical empiricists like Nagel and Hempel, with the corollary that this makes for good science. The basic laws are up at the top, the premises, and the derived laws, the theorems, come further down. Darwin starts with his laws like those of Malthus and about the constant appearance of new variations in populations. Then with all of this in hand, Darwin turns to his consilience and is off and running. The causal picture explains the subareas like social behavior, and they in turn confirm the causal core. Essentially and intentionally, Darwin worked within a physical-science model of good science.

Expectedly, whenever Darwin was challenged about evolution – How can we accept something that in principle is past and hence unobservable? – at once, he raised the wave theory of light (Darwin 1868). In the seventeenth century, Huygens and Newton had proposed rival causal explanations – waves versus particles. Through the eighteenth century, people had accepted Newtonian particle theory and then, at the beginning of the nineteenth century, thanks to such things as Young's double slit experiment, the wave theory had been all-conquering. Whewell (1840) stressed that there is no need of direct observation of waves – they stand at the center of a successful consilience. Precisely the position of his disciple about the tree of life. It is true that there are some elaborations in the *Origin*, for instance the use of the analogy of artificial selection, which hardly stands in the main derivation, but things like this can be readily accommodated within the logical empiricist framework. As we infer waves from their effects, so we infer the tree of life from its effects. Same argument. Darwin's genius, in other words, was to fit right in and do the expected!

There is nevertheless something interestingly different about Darwin's theory (Ruse 2017b). Different in the sense of not fitting the norms of the physical sciences and thus, incidentally, making very dicey any claims by those like Ernest Nagel, who talked of reducing one science to another. Especially, if like Nagel, you think that "reduction" involves showing that one theory is the deductive (logical) consequence of another, and if, also like Nagel, the kind of reduction you have in mind is where the biological sciences are shown as mere consequences of the physical sciences. Know all about molecules and

hence know all about organisms. Questioning this, think yet again about adaptation and its place in Darwin's thinking. The central premise of the argument from design for God's existence is that the world, the organic world especially, is design-like and the conclusion is that the only possible explanation is a designer, God (Ruse 2003). Darwin buys right into the premise. He thinks the eye really is like a telescope. It is just that it is made through law by natural selection rather than miraculously by God. Note however that this means Darwin accepts the legitimacy of the kinds of arguments made famous by Aristotle, namely arguments in terms of "final causes." Instead of asking why there is a banging sound – a nail is being hammered into a block of wood – we ask why the nail is being so hammered – to build a house. We ask what is the purpose or function of so treating the nail? We ask in terms of ends. What end is served by those funny plates on the back of the dinosaur stegosaurus? And we accept answers in terms of ends. The plates function for heat control, raising the temperature in the early morning's sun and holding the temperature at midday thanks to the cooling effects of breezes across the plates.

The trouble for the logical empiricist is that, thanks to the Scientific Revolution, final causes were kicked out of the physical sciences in the sixteenth and seventeenth centuries. It simply was not helpful to ask about ends. You want the dimensions and velocity of the moon, not its purpose – even if one does exist, like lighting the way home for drunken philosophers. Francis Bacon famously referred to such causes as like Vestal Virgins, beautiful but sterile. Even more trouble for the logical empiricist is that, although expelled from physics, they remained in biology, and continued to be interpreted in a theological mode. Darwin seemed to give the needed solution and final causes could go from science, forever. Now, it seems, he let us all down! We are still stuck with final causes. Darwin is quite flagrant about it all. From the *Origin*: "It is now commonly admitted that the more immediate and final cause of the cuckoo's instinct is, that she lays her eggs, not daily, but at intervals of two or three days" (Darwin 1859, 216–217). Spacing them out serves the end of having time to find possible hosts. Even worse, the egg-laying pattern is of value to the cuckoo. It may not be so for the hosts, but for the parasite it is a good. This is anathema to any good philosopher of science brought up post David Hume and his separation of fact from value, of "is" from "ought." Science has no values. It tells it like it is. You really shouldn't say that the plates are of value to the stegosaurus.

Two points temper the wind to the shorn logical empiricist. First, nothing here is violating the ways of the physical sciences. The objection is to absolute value, like saying, because it is the home of human beings, planet Earth is

a better planet than planet Venus. There is no objection to relative value, like that the efficiency of the diesel engine is much better than the efficiency of the gas engine (Ruse 1996). That is all part of the trade of science and engineering. In the biology case – notwithstanding the tendency of some people to pump up the status of human intelligence – it is relative value all the way. No one is saying that in some absolute way it is better to be a stegosaurus rather than a tyrannosaurus; rather, that the stegosaurus with plates tends on average to do better than the stegosaurus without such plates. Second, the final-cause thinking of biology – particularly evolutionary biology – is not a sign that the science is second rate. The simple fact is that organisms are different. Thanks to natural selection, they are design-like. They demand final-cause explanation, in a way that physical objects do not. It means of course that in some sense biology will always be autonomous. That, like death, is something that we all must learn to accept. If not willingly, then at least with grace.[5]

As a bonus, a third point. No Darwinian stresses adaptation to the exclusion of everything else. Darwin always recognized that evolution is messy, with compromises. In the *Origin*, he talked of vestigial organs, good evidence of evolution but clearly not now very end-directed. More generally, Darwin was ever sensitive to what is known as the "form versus function" dichotomy (Russell 1916). On the one hand, organisms have structures and show non-adaptive patterns – mention has been made of the isomorphisms between organisms of very different species. The arm of the human, the foreleg of the horse, the wing of the bird, the flipper of the dolphin. All with similar skeletons. On the other hand, organisms work, because of their parts, their adaptations. At the beginning of the nineteenth century, the German Romantics were ardent formalists, seeing Platonic forms embracing organisms through their isomorphisms (Richards 2003). The English anatomist, Richard Owen (1849), picked up on these ideas. Explicitly acknowledging the great Greek philosopher, he proposed linking archetypes, ideal patterns that underlie physical reality. In France, Georges Cuvier (1817) was no less ardently a functionalist, seeing working parts throughout nature. He spoke of organisms having "conditions of existence," function or teleology.

Darwin was the functionalists' functionalist. This does not mean he denied form, the importance of which he would have learned in the years after the

[5] Nagel tried to get around final-cause thinking by suggesting that it meant simply that we are talking about "goal-directed" systems, like homing missiles that can change course as the target changes course. This he thought has the kind of forward-looking odor we are seeking, while staying strictly in the world of the mechanical. Unfortunately, Nagel was confusing being "adaptable" with being "adapted." An organism might be very well adapted without being able to respond to change at all. I have colleagues like this.

Beagle voyage from his then good friend – later critical rival – Richard Owen. From about 1846 to 1854, Darwin labored on a massive study of barnacle systematics, work that requires form all the way (Darwin 1851a, b, 1854a, b). Indeed, function can be confusing. An adaptation, let us say for swimming, might conceal the true relationships between marine mammals and their land-living cousins. In the *Origin*, there was explicit discussion of form, although it was put in the context of secondary to function.

> It is generally acknowledged that all organic beings have been formed on two great laws—Unity of Type, and the Conditions of Existence. By unity of type is meant that fundamental agreement in structure, which we see in organic beings of the same class, and which is quite independent of their habits of life. On my theory, unity of type is explained by unity of descent. The expression of conditions of existence, so often insisted on by the illustrious Cuvier, is fully embraced by the principle of natural selection. For natural selection acts by either now adapting the varying parts of each being to its organic and inorganic conditions of life; or by having adapted them during long-past periods of time: the adaptations being aided in some cases by use and disuse, being slightly affected by the direct action of the external conditions of life, and being in all cases subjected to the several laws of growth. Hence, in fact, the law of the Conditions of Existence is the higher law; as it includes, through the inheritance of former adaptations, that of Unity of Type. (Darwin 1859, 206)

Function, but not to the exclusion of form.

2 Was There a Revolution?

Revolutions Defined

What we want to know is not just how the *Origin* was received but what the reception meant. We want to know if there really was a Darwinian Revolution, focusing here (more philosophical) on the "revolution" part and leaving until later questions (more historical) about the "Darwinian" part. So, ask first, what is a "revolution"? In the *Oxford Dictionaries* we find: "A forcible overthrow of a government or social order, in favour of a new system." Then a more specific sub-definition, moving in our direction. "A dramatic and wide-reaching change in conditions, attitudes, or operation." Very helpfully, we are given many examples of this kind of revolution in use. Including: "The sexual revolution has swept up young adults in a perilous tailspin." "After utterly destroying the once thriving Indian textile industry, Britain sparked its own industrial revolution." "The molecular genetics revolution of the 1960s swept up many of the brightest young minds."

This all seems straightforward. The pill changed sexual habits virtually overnight. From keeping themselves pure for marriage, young people plunged into ongoing sexual activity. As one who grew up under the first regime, but was around to enjoy the second, it was a big deal, I can attest. More than that, what is being talked about is sufficiently spelled out so that one can take exception to the claim. The real result of the sexual revolution was to liberate young people and point to greater maturity, taking responsibility for one's actions. From sex to machines. Thanks to the Empire builders, or destroyers, a space was opened for Mancunians to build a large, smoky city filled with factories and their workers run by wealthy and powerful businessmen, where once there had been inherited agricultural lands, owned by the aristocrats and gentry owners and worked by their serf-like laborers. And then to molecules. All you must do is listen to the likes of organismic biologists, like the ornithologist and evolutionist Ernst Mayr (1969), to realize that something major was going on. Talking of the overtaking – the "reduction" – of organismic biology by molecular biology he wrote, "it is heuristically a very poor approach. Contrary to the claims of its devotees, it rarely leads to insights at higher levels of integration and is just about the worst conceivable approach to an understanding of complex systems. It is a vacuous method of explanation" (128). This is a man who has seen the future and he doesn't much like it. The students have moved on from birds to double helixes.

We can obviously talk about "revolutions," meaning major changes in the way that we think. This links us up not just to changes in other areas of thinking – Did the Enlightenment lead to greater changes in our ways of thinking about religion than did the Protestant Reformation? – but more generally to all kinds of major changes – Was Marshall McLuhan right in saying that the coming of telecommunications has turned the world into a "global village"? So now, we can turn the question to the Darwinian Revolution, and ask if we got a change that merits the term "revolution." Did we get "a dramatic and wide-reaching change in conditions, attitudes, or operation," where I guess we are concentrating on the "attitudes" part of the definition?

Reception

To answer this question, first sketch out the general story of the reception of Darwinism, waiting until later to go into detail. Everyone realized that the *Origin* was a work of major importance. Before the end of November 1859, the botanist Hewitt C. Watson was writing to Darwin: "You are the greatest Revolutionist in natural history in this century, if not of all centuries"

(Darwin 1985, 7:385, letter to CD, 21 November 1859). Flattery perhaps, but knowingly directed. Already, thanks to his work on geology and then the lengthy study of barnacles – picked up by more than one novelist, including Dickens in *Little Dorrit* who made the Barnacle family the epitome of bureaucratic inaction – Charles Darwin was, in his country's eyes, a major scientist. Because of his account of his travels in his youth, even before the science, he was a public figure. Darwin's book – *The Voyage of the Beagle* – is hugely exciting and entertainingly written, deservedly a Victorian best seller at a time when geographical explorations were of high and continuing interest. South America, around which the *Beagle* spent most of its time, was esoteric and colorful, and the accounts of its denizens, especially the "savages" at the end of the earth, Tierra del Fuego, fascinating and rather frightening.

At once, the *Origin* was picked up and discussed. In the Boxing Day (December 26) 1859 number of the *Times*, Thomas Henry Huxley reviewed the *Origin* in some detail and, despite caveats, very favorably. All over England, conservative squires and clergymen, dining off the remains of dinner the day before, were learning all about evolution through natural selection. Learning about its virtues. "That this most ingenious hypothesis enables us to give a reason for many apparent anomalies, in the distribution of living beings in time and space, and that it is not contradicted by the main phenomena of life and organization appear to us to be unquestionable" (Huxley 1859, 19–20). In the same mode, Charles Dickens ran a weekly magazine, *All the Year Round*, with a circulation of a hundred thousand. In those pre-film and television days, that would probably have meant a readership of about half a million. In 1860, subscribers got a full account of this shocking new theory. "Man, by selection in the breeds of his domestic animals and the seedlings of his horticultural productions, can certainly effect great results, and can adapt organic beings to his own uses, through the accumulation of slight but useful variations given to him by the hand of Nature. But Natural Selection is a power incessantly ready for action, and is as immeasurably superior to man's feeble efforts, as the works of Nature are to those of Art" (Anon 1860a). We learn that this is not gospel, as one might say. That said, those who do not go along are "timid" (Anon 1860b). (The author was the geologist David Thomas Ansted.)

Not all was sweetness and light, as the Victorian poet and essayist Matthew Arnold would have said. There was some immediate opposition. At the 1860 annual meeting of the British Association for the Advancement of Science in Oxford, supposedly the High Church bishop of Oxford, Samuel Wilberforce – son of William Wilberforce of slave-trade-abolition

fame – asked Thomas Henry Huxley whether he was descended from monkeys on his father's side or his mother's side. Supposedly, Huxley responded that he would rather be descended from an ape than from a bishop of the Church of England! Probably mythical, but one of those myths like Moses and the Children of Israel that contains more truth than most literal accounts (Lucas 1979).

For all that Wilberforce was establishment, he was past news. Science belonged to the present and future – it was the young upstart, irreverent and confident. And successful. The idea of evolution as such, evolution as fact, swept the cultural consciousness. The American South had its own issues thanks to the defeat in the Civil War (Noll 2002; Numbers 2006). Otherwise, most people came on board about evolution. It just solved too many problems to be ignored or belittled. By the mid-1860s, undergraduates in biology at Cambridge on the final exam were being told to accept evolution and talk about causes. Frank Darwin, son of Charles, got a first! Even the religious were happy with evolution. To quote again *the* Victorian poet – Alfred Tennyson – showing how everyone can find reason to move on: "The old order changeth yielding place to new And God fulfills himself in many ways Lest one good custom should corrupt the world" ("The passing of Arthur," in Tennyson 1998). Humans were an exception, of course. Our souls demand divine intervention; but for the rest, let nature take its course.

> If single acts would evince design, how much more a vast universe, that by inherent laws gradually budded itself, and then created its own plants and animals, a universe so adjusted that it left by the way the poorest things, and steadily wrought toward more complex, ingenious, and beautiful results! Who designed this mighty machine, created matter, gave to it its laws, and impressed upon it that tendency which has brought forth the almost infinite results on this globe, and wrought them into a perfect system? Design by wholesale is grander than design by retail. (Beecher 1885, 115)

Evolution as theory, natural selection, was otherwise – or so it seems to many, looking back from today. No one wanted to deny it absolutely, but there was a general feeling that as science it was at best not proven, and at worst insignificant. It cleared away the inadequate after real causes had done their work. Huxley (1859) is typical. "After much consideration, and with assuredly no bias against Mr. Darwin's views, it is our clear conviction that, as the evidence stands, it is not absolutely proven that a group of animals, having all the characters exhibited by species in Nature, has ever been originated by selection, whether artificial or natural." If not selection, then what? While some opted for Lamarckism and others for end-directed forces causing momentum in

nonadaptive directions, Huxley himself favored jumps – saltations – from one form to another. Fox into dog in one generation. Huxley was a university professor and his massive course on biology stretched for 165 lectures. There was quite a bit of stuff on Negro teeth size. Natural selection got ten minutes. That tells you something (Ruse 1996).

Things started to change around 1900. Two serious scientific objections had been launched against Darwin's theory. The first, from the physicists, was that the age of the Earth – as calculated from things like the heat coming from the sun – is far too small to accommodate a leisurely process like natural selection. This was answered at the beginning of the new century when the heat-producing properties of radioactive decay were discovered, making the Earth quite old enough for the operation of Darwin's mechanism (Burchfield 1975). The second objection, from the biologists, focused on the absence of an adequate theory of heredity. However effective selection, could it have any lasting effects? Speaking to this, the thinking on heredity by the Moravian monk, Gregor Mendel, was rediscovered. The units of heredity are particulate and thus will not be blended away, willy-nilly. Selection can have lasting effects (Bowler 1989).

Rapid was the development and extension of a new theory – the "classical theory of the gene" – putting the units of heredity on the chromosomes within the nuclei of cells. Mathematicians showed how this thinking could be extended to groups, population genetics, and then in the 1920s key researchers – Ronald Fisher and J. B. S. Haldane in Britain and Sewall Wright in America – showed how this provided a stable foundation for the working of Darwinian natural selection (Provine 1971).[6] Very soon, on the theoretical skeleton of the population geneticists, the hands on-researchers – notably E. B. Ford in Britain and Theodosius Dobzhansky in America – added the empirical flesh of laboratory and field studies (Ruse 1996). Finally, Darwin's theory reached the Promised Land. We now had – and still very much have – a selection-based, working theory: neo-Darwinism (British name) or the synthetic theory of evolution (American name). As mentioned in the Prologue, major advances came starting in the 1950s with the arrival of molecular biology, today an integral part of evolutionary studies, and then in the 1960s with the development of new models studying social behavior.

[6] Note how this led to a crucial move on from Darwin's vision (Ruse 1973; Sober 1984). Natural selection was just as crucial for Fisher and Haldane as it was to Darwin – less so for Wright, who toyed with nonadaptation-producing mechanisms, like genetic drift, a function of mere chance. But whereas Darwin introduced selection at the top of his theory, as it were, for the population geneticists, genetics was at the top – specifically the Hardy-Weinberg Law that gave the kind of equilibrium conditions guaranteed in physics by the First Law of Motion – and then selection introduced as a disruptive factor, a bit like gravity.

"Dramatic and Wide-Reaching Change"?

That's the sixty-four-thousand-dollar question. For the moment, let us give natural selection to the critics – to those who argue that there was no revolution and the fate of natural selection proves that. Turn to the matter of evolution as fact, the claim that instead of being the miraculous creation of a good god over the course of six days – however interpreted – organisms are the end products of a long, slow, natural process of change, making a tree of life. Surely if anything was "dramatic and wide-reaching change," it was this.

> If I did not think you a good tempered & truth loving man I should not tell you that, (spite of the great knowledge; store of facts; capital views of the corelations of the various parts of organic nature; admirable hints about the diffusions, thro' wide regions, of nearly related organic beings; &c &c) I have read your book with more pain than pleasure. Parts of it I admired greatly; parts I laughed at till my sides were almost sore; other parts I read with absolute sorrow; because I think them utterly false & grievously mischievous— (Darwin 1985, 7: Letter from Sedgwick to CD, 24 November, 1859)

This is one of Darwin's old mentors from his Cambridge days, the geologist Adam Sedgwick. He is emoting away, as Sedgwick was wont to do – he followed an 85-page critique of *Vestiges* by introducing the reprint of a mild little sermon on undergraduate behavior with a 500-page, anti-*Vestiges* diatribe, and then for good measure added a 300-page conclusion, also on the sins of that vile, anonymously authored piece of filth.

Sedgwick's denunciation, with the hardly less emotionally powerful, positive response of Hewitt Watson, shows that the coming of evolution was certainly big. Was it big science? Here it is convenient to make a threefold distinction. At one end of the scale, we have what we might call *pseudoscience*. This is a body of assertions, claiming to be science in the sense of talking about the real, empirical world, but truly motivated only by ideological claims – that could be religious or political or social (Ruse 2013b). Values are what drive it. In 1981, from Canada (where I then worked) I went down to the state of Arkansas, as an expert witness for the American Civil Liberties Union. Along with such scientific luminaries as Stephen Jay Gould, together with the leading Christian theologian Langdon Gilkey, I testified on the nature of so-called Scientific Creationism, something the legislators were then insisting be taught in the publicly funded schools of the state. Especially in the "Young Earth" version, it is a paradigmatic case of a pseudoscience. A somewhat idiosyncratic, literalistic reading of the early chapters of Genesis, it argues that the origins of organisms and their home, planet Earth, occurred about six

thousand years ago, over the course of six days, culminating in humans. Some years later, the clock was moved back and much had to start again, thanks to a worldwide flood that wiped out everything that could not be packed into a conveniently built houseboat, the Ark.

All of this is nonsense. Spelled out in 1961 in *Genesis Flood*, authored by a Princeton-educated, biblical scholar and a hydraulic engineer, Scientific Creationism was intended to provide a way around the constitutional separation of church and state (Ruse 1988). Supposedly, this version of Creationism is not religious. There is scientific evidence for every one of its claims. Of course, the truth is otherwise. Invented solely to support the values and beliefs of these extreme evangelical Christians, this version of Young Earth Creationism went against just about every scientific idea ever proposed, from the origins of the universe, to the appearance of organisms, to the incredulity of universal deluges in the age of continental drift. Although Scientific Creationism is still accepted today by about half of the American population, it was and is the personification of pseudoscience.

At the other end of the scale, we have *professional science* (Ruse 2017a). This is what Herschel and Whewell were talking about. It is what, setting the background for scientific revolutions, Kuhn refers to as "normal" science. It is produced in universities today in departments of physics and chemistry. It is an enterprise dedicated to understanding the empirical world as a function of unbroken law, explanations bound together in logical systems. Sociologically, it is something that requires training and grants and so forth. Then in the middle, we have *popular science* (Ruse 2017a, 2018). It is more than pseudoscience but less than professional science. It is what we find in magazines like *Scientific American* or the Tuesday science section of the *New York Times*. In a somewhat negatively jocular sort of way, we might say that it is professional science without the mathematics! There are more positive aspects. In respects, in communicating to the public (who are usually footing the bills), popular science has it over professional science. Above all, popular science is not pseudo. One could have a perfectly acceptable, popular account of something like continental drift. Some professional scientists, like Carl Sagan and Stephen Jay Gould, have made whole second careers out of doing popular science. Unlike professional science but like pseudoscience, popular science can contain (absolute) values. Professional science can tell us about whether there is or is not global warming. Popular science can talk about whether or not this is a good thing. Pseudoscience tells us that it does not exist.

Our history shows us that, until the time of Darwin's *Origin*, evolutionary thinking rarely if ever got above the level of the pseudo. It rode on the back of

the cultural concept and hope of Progress (Ruse 1996). The evidence was absent and the values all-determining. This does not mean it was never popular. Creationism is very popular and, especially after Chambers, evolution became very popular. Always with a quick eye for trends, the future Prime Minister Benjamin Disraeli picked up on this. He has one of his flightier characters (in the novel *Tancred*) enthuse about it: "First there was nothing, then there was something; then, I forget the next, I think there were shells, then fishes; then we came, let me see, did we come next? Never mind that; we came at last. And the next change there will be something very superior to us, something with wings. Oh! that's it; we were fishes, and I believe we shall be crows." Continuing: "It is impossible to contradict anything in it. You understand, it is all science; it is not like those books in which one says one thing and another the contrary, and both may be wrong. Everything is proved; by geology, you know" (Disraeli 1847).

Evolution as Fact

It was Darwin's aim to move, in one leap, from the pseudo to the professional. Continuing to leave causes on one side, ask now in these terms, did evolution as science – evolution as fact – move up to the realm of professional science?[7] Was Darwin's work revolutionary in this sense? It certainly seems that something big and revolutionary – something big and revolutionary in professional science – went on in the nineteenth century. At the beginning of the century, the general position was that, thanks to the creative powers of the God of Abraham, organisms come about through miracle. Perhaps not literally, as in the bible, but certainly Providentially. Whewell (1837) discussed and rejected natural origins. On this subject, "geology is silent." Adding: "The mystery of creation is not within the range of her legitimate territory; she says nothing, but she points upwards." (3, 588) At the end of the century, through development from other forms, people believed in natural origins of organisms. In 1893, in his essay "Evolution and Ethics," Huxley wrote: "Man, the animal, in fact, has worked his way to the headship of the sentient world, and has become the superb animal which he is, in virtue of his success in the struggle for existence." No God. No miraculous creation. No Garden of Eden. We are in a different world.

[7] Note that I am treating of the fact, the tree, before the cause, selection, purely for purposes of exposition. I do not regard this as implying that for Darwin the cause was or should be secondary. I regard Darwin's proper ordering of function over form as evidence that the cause is primary. Here I differ from Elliott Sober (2011) who, presumably less passionate about adaptation than I, puts the tree before selection and criticizes Darwin for not spotting this.

Qualifying but not denying, notice that we don't have here the arrival of a new, formal, laws-and-deductions, scientific theory. That is the whole point. We have the conditions for such a theory. If you are going to have professional science, then you must have a naturalistic world picture, and it is precisely this that Darwin is offering. That is what evolution as fact is all about. "To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of the individual" (Darwin 1859, 488). In other words, evolution as fact is in many respects a kind of metaphysical claim about how things work – naturalistically or super-naturalistically. This is so much so, one might be tempted to say that, as far as professional science is concerned, there was no revolution at all! After the *Origin*, in America, although Asa Gray, the Harvard botanist, was Darwin's great supporter, the man who had the greatest influence on the next generation of biologists was one who denied evolution. Gray's colleague at Harvard, Louis Agassiz, Swiss immigrant, geologist (it was he who came up with the Ice Age theory), and morphologist and systematist, stood firm against such thinking (Agassiz 1859). He had many students. They all, including his own son, eventually became evolutionists. Notoriously, it can be difficult on reading their papers to determine if they have yet made the move. The science is silent! Paleontologist Alpheus Hyatt is a case in point. Admired by all, including Darwin, it was impossible to tell from the written word exactly where he stood on evolution (Ruse 1996). Hyatt was almost deliberate. He didn't want evolution to get in the way of his science. Thirty years after the *Origin*, he warned against teaching evolution to the students. "We strongly advise teachers not to use this or any theory in teaching immature minds." Continuing: "Immature minds ought to employ the time wholly in observing, the handling of theory being not only beyond their grasp but injurious, because it leads them to neglect the work which they can do well for a game at speculative guessing" (Hyatt 1889, 276). He co-authored a little book on the insects in a "guides for science-teaching" series exemplifying this philosophy (Hyatt and Arms 1890).

No evolution at the professional level? This is one-sided. Metaphysics aside, there were empirical facts being pushed – not just evolution but the form of the evolution, specifically that it traced out a tree of life. Although this metaphor goes back to the eighteenth century – the great naturalist Georges-Louis Leclerc, le Comte de Buffon, toys with it – Lamarck never subscribed to it (Ruse 1979). He believed that new primitive forms were being created,

spontaneously and continuously. These then moved upwards in parallel lines, going through the same forms, more or less – more because of the teleological vital force, less thanks to the disturbing effects of Lamarckism, the inheritance of acquired characteristics. For Darwin if, say, lions go extinct, that is it. For Lamarck, it is simply a question of time, for lions will reappear as another later line brings them into being. Flipping to the end of the nineteenth century, in paleontology it really would have made little sense to pretend that it was all metaphysics and one didn't really need to suppose evolution. If one finds in the record a life form and then somewhat higher a slightly different form, to say that they were not connected through evolution would be to go back to Whewell and to say simply that one has no explanation.

Biogeography was an even stronger case in point. In the *Origin*, Darwin had pointed to the similarity of Galapagos Archipelago organisms to those of South America and to Cape de Verde Island organisms to those of Africa. To deny evolution was again to relinquish any scientific explanation.

> . . . there is a considerable degree of resemblance in the volcanic nature of the soil, in climate, height, and size of the islands, between the Galapagos and Cape de Verde Archipelagos: but what an entire and absolute difference in their inhabitants! The inhabitants of the Cape de Verde Islands are related to those of Africa, like those of the Galapagos to America. I believe this grand fact can receive no sort of explanation on the ordinary view of independent creation; whereas on the view here maintained, it is obvious that the Galapagos Islands would be likely to receive colonists, whether by occasional means of transport or by formerly continuous land, from America; and the Cape de Verde Islands from Africa; and that such colonists would be liable to modification;—the principle of inheritance still betraying their original birth-place. (Darwin 1859, 398–399)

In the same vein, Wallace (1876) did sterling work on the biogeography of the denizens of the Far East, showing a clear division between those of Asian origin and those of Australian origin. Known as Wallace's Line, the division runs through Indonesia, between Borneo and Sulawesi (Celebes), and through the Lombok Strait between Bali and Lombok. None of this makes any sense – certainly not sense as professional science – unless one assumes the fact of evolution. The causes must be filled in, whether selection or not, whether continental drift or not, but those are additional questions, not alternative questions.

Natural Selection

Turn now to these additional questions. Grant that for all that it is the dominant mechanism in evolutionary studies today, natural selection was certainly not an immediate smash hit in the world of professional science. Grant that – putting

aside direct objections like the age of the Earth and problems with heredity – there were at least two good reasons for this (Ruse 1996). On the one hand, as already hinted, a lot of the contemporary science had little immediate use for selection. This is certainly true in areas like morphology, where the powerful figures like Thomas Henry Huxley made their ways. Indeed, the role of selection in promoting adaptation can be counterproductive, for as we have seen, the latter can conceal vital similarities. On the other hand, another even more important point, selection seemed of little practical use, crucially in areas like medicine where the professional scientists were finding their support. It doesn't cure a pain in the belly. Add its rather controversial nature and in the world of school teaching we end up with professional evolutionists like Alpheus Hyatt who wanted even evolution, let alone selection, kept firmly from the minds of young people.

However, at the professional level, this is not quite the whole story. Today, the place where you see selection in action is in fast-breeding organisms – above the micro-level, most obviously insects. Almost from the first, if not now appreciated for their full worth, there were many insect-based selection studies going on! Butterfly collecting was a hugely popular hobby in Victorian England. The collectors knew all about selection and were sensitive to its effects. They had good models. In the early 1860s, Wallace's South American traveling companion Henry Walter Bates (1863) had come up with an explanation of butterfly mimicry. He hypothesized – and backed this with experiments – that nonpoisonous butterflies mimic poisonous ones to avoid being eaten by predators, birds. This is brought about by natural selection. Then in the next decade the German-born Argentinian scientist, Fritz Müller (1879), came up with another form of mimicry in butterflies and likewise gave it a selective explanation. More generally, the lepidopterists were hard at it, using selection all the way. Because collectors prize rarities – a five-pound note of the wrong color – they were highly sensitive to variations and how their frequency might vary. In the 1840s, a dark form might be very rare. By the 1870s, it might be quite common. Why? Everyone knew all about factories and the consequent pollution – a Victorian obsession given the horrendous peasoupers. Shades of Sherlock Holmes! This all led to an intense interest in industrial melanism, where insects adopt camouflage to hide themselves from predatory birds. The tasty morsels are concealed against ever-more filthy trees.

One enthusiast actually wrote to Darwin.

> My dear Sir,
> The belief that I am about to relate something which may be of interest to you, must be my excuse for troubling you with a letter.

> Perhaps among the whole of the British Lepidoptera, no species varies more, according to the locality in which it is found, than does that Geometer, Gnophos obscurata. They are almost black on the New Forest peat; grey on limestone; almost white on the chalk near Lewes; and brown on clay, and on the red soil of Herefordshire.
>
> Do these variations point to the "survival of the fittest"? I think so. It was, therefore, with some surprise that I took specimens as dark as any of those in the New Forest on a chalk slope; and I have pondered for a solution. Can this be it?
>
> It is a curious fact, in connexion with these dark specimens, that for the last quarter of a century the chalk slope, on which they occur, has been swept by volumes of black smoke from some lime-kilns situated at the bottom: the herbage, although growing luxuriantly, is blackened by it.
>
> I am told, too, that the very light specimens are now much less common at Lewes than formerly, and that, for some few years, lime-kilns have been in use there.
>
> These are the facts I desire to bring to your notice.
>
> I am, Dear Sir, Yours very faithfully,
>
> A. B. Farn
>
> Letter from Albert Brydges Farn on November 18, 1878 (Darwin Correspondence Project, 11747).

Darwin seems not to have responded to this letter. Combined with other suggestive points – although he was very excited by Bates's work, in later editions of the *Origin* he introduced it almost at the end rather than on the first page – one has the nigh-heretical suspicion that, as a working scientist, Darwin was not always that Darwinian! After all, his main biological work had been morphological on dead, marine invertebrates. Even when he did turn to using his theory, the work on orchids particularly, it was all working out morphology and giving it adaptive causes. Professionally, Darwin never thought of doing his science in a dynamic population manner. He never thought of seeing selection effectively in action. Paradoxically, when he was under pressure from the age-limiting thinking of the physicists, he turned to Lamarckism to speed things up. Had I been he, I would have brought out a new edition of the *Origin* with Farn's letter on the title page.

Be this as it may, however they supported themselves, those who worked on insects were very professional in their science. "I believe . . . that Lancashire and Yorkshire melanism is the result of the combined action of the 'smoke,' etc., plus humidity [thus making bark darker], and that the intensity of Yorkshire and Lancashire melanism produced by humidity and smoke, is intensified by 'natural selection' and 'hereditary tendency'" (Tutt 1890, 56).

They were joined by full-time academic professionals, E. B. Poulton (1890) at Oxford and then at the end of the century by W. F. R. Weldon (1898) at University College in London. The latter did tremendous studies of marine organisms, experimenting and showing the effects of selection. Nothing non-Darwinian here!

For thirty-five years, I was in a humanities adjunct to an agricultural college. I suspect there is another area of selection studies that we have underestimated. I refer to those working in breeding – formulating theories and studying practices. Darwin was right. In the farmyard, you use selection all the time. It is easy to move out into nature. People did it before Darwin, and the young scientist read an account of this. It was in a pamphlet on sheep by Sir John Sebright.

> A severe winter, or a scarcity of food, by destroying the weak or unhealthy, has all the good effects of the most skilful selection. In cold and barren countries no animal can live to the age of maturity, but those who have strong constitutions; the weak and the unhealthy do not live to propagate their infirmities, as is too often the case with our domestic animals. To this I attribute the peculiar hardiness of the horses, cattle, and sheep, bred in mountainous countries, more than their having been inured to the severity of climate . . . (Sebright 1809, 15–16)

Darwin took careful note of this passage, and even though he could not quite see the full import grasped that, if something like this went on long enough, we would get full-blooded species. "Sir J. Sebright – pamphlet most important showing effects of peculiarities being long in blood. ++ thinks difficulty in crossing race – bad effects of incestuous intercourse. – excellent observations of sickly offspring being cut off so that not propagated by nature. – Whole art of making varieties may be inferred from facts stated. —" (Barrett et al 1987, C, 133). The artificial/natural selection analogy ran deep.

In the post-*Origin* era, agriculturalists took selection seriously. In the 1920s, those three great gifted biologists who created population genetics, the mathematical skeleton of modern neo-Darwinian evolutionary theory – Fisher and Haldane in Britain and Wright in America – all held posts in and were supported by agriculture. That is where the money was and that is where the selection studies were. Even earlier than this, before the coming of Mendelian genetics, agriculturalists were making use of selection. At Cornell University in upstate New York, writing in 1893, the entomologist and taxonomist John Henry Comstock, hugely influential thanks to texts that he himself published, gave advice to young researchers. If you want to classify organisms, you must go at the job one step at a time, starting with the single, isolated organ.

> First the variations in form of this organ should be observed, including paleontological evidence if possible; then its function or functions should be determined. With this knowledge endeavour to determine what was the primitive form of the organ and the various ways in which this primitive form has been modified, keeping in mind the relation of the changes in form of the organ to its functions. In other words, endeavour to read the action of natural selection upon the group of organisms as it is recorded in a single organ. The data thus obtained will aid in making a provisional classification of the group. (Comstock 1893, 41)

This does not read like the thinking of a man who has turned his back on natural selection as a causal tool of modern professional evolutionary biology.

Popular Science

In the professional realm, it is just not true that natural selection made no inroads. Where it might have been expected, it is found. This is but part of the story, for now we must double back to the realm of popular science. Already, we have had intimations that Darwin's ideas – evolution and, even more, natural section – made quick inroads here. They were there in 1860 in the articles in Charles Dickens's weekly, *All the Year Round*, and then two years later, in 1862, there was a little tale about natural selection in Thackeray's *Cornhill Magazine.* "If it be not the truth, I cannot help respecting it as sincere effort after truth" (Dixon 1862, 318). This was just the beginning, little ripples anticipating a massive tsunami now on its way. Things struck forcibly – and note that it is always selection that is in the forefront, not just evolution – at the walls of the realm of the Christian deity (Ruse 2010, 2015). It wasn't so much about whether or not He exists. Although many, notably the so-called New Atheists like Richard Dawkins (2006) and Daniel Dennett (2006), take the *Origin* as a clarion call to atheism, Darwin was more nuanced. He continued to believe at least in the existent of the god of deism, an unmoved mover, even though later he slid into agnosticism.

The real issue was whether or not God cares for us. The poet and future novelist, Thomas Hardy, raised a good Anglican, saw fully the devastating implications of the blind forces of struggle and selection.

> IF but some vengeful god would call to me
> From up the sky, and laugh: "Thou suffering thing,
> Know that thy sorrow is my ecstasy,
> That thy love's loss is my hate's profiting!"
>
> Then would I bear, and clench myself, and die,
> Steeled by the sense of ire unmerited;

> Half-eased, too, that a Powerfuller than I
> Had willed and meted me the tears I shed.
>
> But not so. How arrives it joy lies slain,
> And why unblooms the best hope ever sown?
> –Crass Casualty obstructs the sun and rain,
> And dicing Time for gladness casts a moan . . ..
> These purblind Doomsters had as readily strown
> Blisses about my pilgrimage as pain.
>
> (Hardy 1994, 5)

If only God hated us and hurt us. We could live with that. Things are far worse. God is indifferent. He could not care less.

We are right in the popular realm. Science for the people with lots of values. Exciting but worrying. Before long, people started to pick up and see the positive side to things. Take that greatest of Shakespeare sonnets about the love between young people.

> Shall I compare thee to a summer's day?
> Thou art lovelier and more temperate.

Why? Because temporal things fall short of perfection.

> Rough winds do shake the darling buds of May,
> And summer's lease hath all too short a date.
> Sometime too hot the eye of heaven shines,
> And often is his gold complexion dimmed;
> And every fair from fair sometime declines,
> By chance, or nature's changing course untrimmed.

This will not be true of you. Your beauty will persist.

> But thy eternal summer shall not fade
> Nor lose possession of that fair thou ow'st;
> Nor shall death brag thou wand'rest in his shade,
> When in eternal lines to time thou grow'st,
> So long as men can breathe or eyes can see,
> So long lives this, and this gives life to thee.

There is something ethereally idealistic – Christian in thoughts of eternity – about the whole picture. One doesn't have the sense that the object of the poet's adoration ever had to do a day's work, or grab a sandwich on the run, or – dare one say it – attend to the demands of bodily functions. One presumes that none of these things comes up in heaven either. Now listen to the late-Victorian poet Constance Naden poking fun at young people and their emotions. She called the poem "natural selection." Really, it was

sexual selection in play, a mechanism most found far more immediately insightful.

I HAD found out a gift for my fair,
I had found where the cave-men were laid;
Skull, femur, and pelvis were there,
And spears, that of silex they made.

But he ne'er could be true, she averred,
Who would dig up an ancestor's grave–
And I loved her the more when I heard
Such filial regard for the Cave.

My shelves, they are furnished with stones
All sorted and labelled with care,
And a splendid collection of bones,
Each one of them ancient and rare;

One would think she might like to retire
To my study–she calls it a "hole!"
Not a fossil I heard her admire,
But I begged it, or borrowed, or stole.

But there comes an idealess lad,
With a strut, and a stare, and a smirk;
And I watch, scientific though sad,
The Law of Selection at work.

Of Science he hasn't a trace,
He seeks not the How and the Why,
But he sings with an amateur's grace,
And he dances much better than I.

And we know the more dandified males
By dance and by song win their wives–
'Tis a law that with Aves prevails,
And even in Homo survives.

Shall I rage as they whirl in the valse?
Shall I sneer as they carol and coo?
Ah no! for since Chloe is false,
I'm certain that Darwin is true!

(Naden 1999, 207–208)

This is someone writing confidently in the world of Charles Darwin and who expects her audience to be up on these things. There has been evolution, we are part of the picture, and natural (and sexual) selection is responsible. The poet tells us that humans behave not much differently from birds, but the in-joke is

that we have evolved little beyond the cave men – sexy show over serious substance. If, from the darling buds of May, cave men are not a "dramatic and wide-reaching change in conditions, attitudes, or operation," then I don't know what is. At the level of popular science, there was a revolution.

3 What Kind of Revolution?

Let's keep digging. There was something we can call revolutionary. Time now to ask about the nature of scientific change. Very obviously, we turn to Thomas Kuhn's *The Structure of Scientific Revolutions*. Our interest is not in Kuhn as such, but in seeing what light his thinking throws on the Darwinian Revolution.

Kuhn on Science

Thomas Kuhn propounds a very definite view of scientific revolutions. The key notion is that of a "paradigm," something that Kuhn loosely defines as a body of achievement seducing people away from other perspectives or paradigms and that crucially gives work to active scientists. A paradigm is like a scientific theory, but it is more than that. It is a kind of trade, something that you must learn – knowing how as well as knowing what – which is why the apprentice process is so important in science. You practice a craft and work from within, with fellow initiates, knowing and obeying the rules, implicit and explicit.

> Aristotle's Physica, Ptolemy's Almagest, Newton's Principia and Opticks, Franklin's Electricity, Lavoisier's Chemistry, and Lyell's Geology—these and many other works served for a time implicitly to define the legitimate problems and methods of a research field for succeeding generations of practitioners. They were able to do so because they shared two essential characteristics. Their achievement was sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity. Simultaneously, it was sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve.
>
> Achievements that share these two characteristics I shall henceforth refer to as 'paradigms,' a term that relates closely to 'normal science.' (Kuhn 1962, 10)

If change of paradigms is "revolutionary science" – the Merriam-Webster dictionary actually gives a definition of revolution in terms of change of paradigm – then working from or within the paradigm is (what we have already encountered as) "normal science." The important thing is that working within the paradigm means that the basic premises are not up for discussion. They are

fixed like the dogmas of Christianity. Hence, scientists face puzzles, not problems. A puzzle, as you find in a crossword, has a solution. If you cannot find it, the fault is yours, not the paradigm's. Problems do not necessarily have a solution. Teenagers.

Kuhn has some discussion of pre-paradigmatic science, when there is no normal science, just floundering about. Once you have a paradigm, though, the question is why one would ever want to change it. Why not normal science forever? Kuhn suggests that more and more one is faced with puzzles that seem insoluble – anomalies – giving rise to the suspicion that they may be problems, not puzzles. But you keep going until someone comes up with another paradigm that solves or avoids the anomalies, and offers prospects of more work, normal science. Then change takes place, the textbooks are rewritten – shades of *1984*, making it all seem as though nothing had happened – and normal science recommences.

Although Kuhn was to qualify and deny in later writings, it is important to recognize how the fundamental underlying philosophy of this picture is idealism. There is no ultimate reality. Paradigms define and make it. That means that, appearances otherwise, paradigms do not overlap. They are "incommensurable." The change of paradigm, ultimately, must be like a political or religious experience. You live a humdrum life without much meaning, just going through the motions in a job you don't much like, in relationships that have become boring. Suddenly, thanks to a TV show watched randomly, you see it makes sense of your life to accept Jesus as your savior. All the problems you had before, perhaps about sin, fall into place and you can see that solutions are possible. You change jobs to something of value, serving others. You change relationships or, more likely, you invigorate those you have, perhaps by converting them too. The important thing is that there is no algorithm dictating that first leap of faith, however satisfying it might then prove. The same in science.

> Like the choice between competing political institutions, that between competing paradigms proves to be a choice between incompatible modes of community life. Because it has that character, the choice is not and cannot be determined merely by the evaluative procedures characteristic of normal science, for these depend in part upon a particular paradigm, and that paradigm is at issue. When paradigms enter, as they must, into a debate about paradigm choice, their role is necessarily circular. Each group uses its own paradigm to argue in that paradigm's defense. (Kuhn 1962, 94)

One can see why Karl Popper and his groupies were so opposed. Popper's claim to philosophical fame rests on his well-known "criterion of demarcation" between science and non-science: falsifiability (Popper 1959). You can never

show something is absolutely true. You can always show that it is absolutely false. Making a virtue of necessity, for Popperians the ever-present threat of falsification is the force making for potential advance. It is something guided by logic. Either, for now, the hypothesis stands up, or it falls. And if it falls, then you search around for something new that will do the job, at least for this future now. There is no choice in the matter. At least, there is no place for emotion in one's choice. One does have an algorithm. Conversion experiences are the mark of metaphysics, not of real science. It is little surprise therefore that Kuhn and Popper differed over the course of science and its relationship to reality. What is a surprise is that evolution appealed to both of them. For Kuhn, there is no ultimate reality. Hence, paradigm change is not going anywhere in the sense of Progress, getting toward the truth. However, as in Darwinian evolution, some organisms do better than others, for a while at least, so there is that kind of relative P/progress. Reptiles over fish, mammals over reptiles. Copernicus over Ptolemy. Nothing absolute. Fish still do well in the sea. Reptiles do well in their way too. Mariners assume the Earth is at the center of the universe. For Popper there is an ultimate reality and science is getting ever closer. Evolution in that sense. We will never get there – it is like Kafka's castle in that respect – but things really are getting better. Copernicus over Aristotle, Einstein over Newton. We know more than we did.

Before the *Origin*

Kuhn's fellow historians of science have always been skeptical about how far any of this applies to the Darwinian Revolution. Even if something important did happen, many doubt it was very Darwinian. James Secord (2000), *Vestiges* chronicler, goes so far as to say, "a Darwin-centered account is no longer credible" (4). If you give Darwin a central role, this is simply because he was one of many! There was no single paradigm before the *Origin* and among the contenders were those that entirely anticipated the ideas of the *Origin*. The eminent historian of biology, John C. Greene (1981), is pretty sniffy. He finds coexisting paradigms all over the place. In the context of our earlier discussion, we find both functionalists and formalists. There was the functionalist anatomy of Cuvier, who argued to the impossibility of evolution because of the tightly structured, functional nature of organisms – what Darwin picked up on as their "conditions of existence." Here also, balancing, there was Lamarckian evolution, with the teleological drive up the chain of being, somewhat disrupted by the side effects of the inheritance of acquired characteristics. Then, there was the formalist German Romantic biology, *Naturphilosophie*, which stressed the unity of life, focusing on isomorphisms rather than

adaptations. Some were non-evolutionists; some were evolutionists. The great German poet, Johann Wolfgang von Goethe, in his long life, passed from the one to the other. So too probably did Richard Owen. Above all, there was *Vestiges*, although heaven alone knows what Robert Chambers, the anonymous author, thought were the causes.

One could presumably say that biology at this point was in a pre-paradigmatic state that changed only with the *Origin*. This doesn't seem entirely right, because people don't seem to be floundering; although it is certainly true that "different men confronting the same range of phenomena, but not usually all the same phenomena, describe and interpret them in different ways" (Kuhn 1962, 17). A good case – based on Cuvier and (the early) Owen – can be made for saying that the non-evolutionists did work that was better than the evolutionists' work. Everyone recognized that Lamarck was a good systematist, but when it came to the bigger picture Cuvier won hands down. In the Kuhnian sense of normal science, the work was better, more fruitful. Cuvier gave you puzzles to work on and solve, unlike Lamarck. The same is true of Owen. If paradigm status is conferred by providing the scope for normal science, then the non-evolutionary picture broadly construed seems to qualify. Paradoxically, after he had become an evolutionist, Darwin did some of his best normal science within it. I refer to the eight years around 1850 that he spent on the massive project on barnacle anatomy and taxonomy. Reading back, we can see a lot of scope for evolution in what Darwin did, but the work was more Owen than Darwin. Very professional and so judged. The Royal Society awarded Darwin a medal.

Perhaps it is better to think of the bigger picture, and say that metaphysically first we had non-naturalism, which meant non-evolution – presumably divine interventions – and then second, naturalism, which meant evolution. Interpreting things this way means that, in respects, the coming of the *Origin* was quite Kuhnian. The emoting of people like Sedgwick shows that something akin to a political or theological conversion is going on. Sedgwick on Darwin is a little bit like Luther on the Pope or his successor in the White House on President Obama. Hempel and Nagel do not prepare you for this, nor does Popper with all his emphasis on rationality. Yet before you close the discussion and go home, another objection comes up. If one allows that one of the pre-*Origin* paradigms was naturalistic evolution, doesn't this just downgrade the Darwinian element in all of this? Does one want to say that the *Origin* is a new paradigm? One does not deny that something big happened in science; it is rather a question of who should get the credit. Raise again the distinction between evolution as fact and evolution as cause, meaning natural selection. Although no one quite tied in the fact of evolution with the tree of life as did

Darwin, there were certainly evolutionists per se – Erasmus Darwin, Lamarck, Chambers, to name those already in our story, and there were yet others like the physician Robert Grant and then from around 1850 on (and on and on and on) Herbert Spencer. Obviously, Kuhn must be wrong in some sense. We do not get a complete change of worlds, pre- and post-*Origin*. There is continuity.

Let us grant this point. Notwithstanding, something important did happen, and it was due to Charles Darwin and to him alone. This was to establish the fact of evolution through his consilience. Evolution was no longer something that came in on the back of the cultural notion of Progress. Although he wanted something akin to biological progress, Darwin knew what was going on and was clear that his thinking was not an epiphenomenon of Progressivist thinking – as had been that of his grandfather and other pre-*Origin* evolutionists.

> The enormous number of animals in the world depends of their varied structure & complexity. – hence as the forms became complicated, they opened fresh means of adding to their complexity. – but yet there is no necessary tendency in the simple animals to become complicated although all perhaps will have done so from the new relations caused by the advancing complexity of others. (Barrett et al. 1987, E 95)

Grant this much to Darwin. What about the cause of evolution? Already we have seen that Darwin was not the first to think of natural selection, if not by that name. In the year of his birth, John Sebright was thinking along these lines, and there were others, including the physician William Wells and the arborealist Patrick Matthew, not to mention by mid-century the indefatigable Herbert Spencer. Thanks to the struggle for existence, "as those prematurely carried off must, in the average of cases, be those in whom the power of self-preservation is the least, it unavoidably follows, that those left behind to continue the race are those in whom the power of self-preservation is the greatest—are the select of their generation" (Spencer 1852, 499). Darwin read Sebright. This does not make him a plagiarist or deny that he was supremely important in his own right. Apart from the fact that Spencer was writing over a decade after Darwin had seized on selection, it was Darwin uniquely – until Wallace appeared in 1858 – who seized on selection as a mechanism of evolutionary change and who made much of it. Spencer mentioned it only in passing, and the same is true of others.

After the *Origin*

What about the time after 1859? The historian Peter Bowler has made somewhat of a cottage industry out of this one (Bowler 1983, 1988, 2005, 2013). Actually, he seems a bit torn. Sometimes the suggestion is that Darwin did have some

effect, but it was almost universally bad. Bowler's latest book is called *Darwin Deleted*! If the young naturalist Charles Darwin had fallen over the side of the *Beagle* in the early 1830s, what would have happened? Much that is familiar. "Darwin certainly rocked the boat, but he did not steer it onto a completely new and dangerous course." Things would probably have been smoother. "There would be less tension between science and religion, since one of the major battles in what we see as the war between them would never have been fought" (Bowler 2013, 279). At other times, the suggestion is that Darwin didn't really have much effect at all, and as for natural selection, what a flop! It calls for a Trump Tweet. Bowler writes of "the myth of the Darwinian Revolution," concluding his discussion saying it "seems unreasonable for historians to claim that the turning point in the emergence of modern culture should be called a 'Darwinian Revolution.'"

How can the Darwinian Revolution be a Kuhnian Revolution, when it isn't Darwinian? At best, we have a revolution that transcends Darwinism. Perhaps the metaphysical move from non-naturalism to naturalism.[8] Secord (2000) suggests that "what once made sense as the 'Darwinian Revolution' must be recast as an episode in the industrialization of communication and the transformation of reaching audiences" (52). If you want to stay with science, perhaps we do have a successful or dominant paradigm, but it is that of someone else. Perhaps Spencer. Perhaps Lamarck. This seems to have been the position of the American biologist Vernon Lyman Kellogg who, in 1905, wrote that "Darwinism, as the all-sufficient or even most important causo-mechanical factor in species-forming and hence as the sufficient explanation of descent, is discredited and cast down." In its place, he offered "when species differences and adaptations are identical with differences and modifications readily directly producible in the individual by varying environment, are we not justified, on the basis' of logical deduction, to assume the transmutation of ontogenetic acquirements into phyletic acquirements . . . ?" (382). At worst, we seem to have no paradigm at all. This seems to have been the way that Greene was thinking. "In fact, it could be argued that nothing approaching a 'Darwinian' paradigm became established until the 1930s, and even that paradigm was Darwinian only in a very loose sense." I told you he was pretty sniffy.

Responding, drawing on the discussion in the last section, one thing we can say straight off is that, with respect to causation, Darwin really did himself provide something, and that, at the professional and even more at

[8] For a while, Karl Popper argued that evolution through natural selection is a metaphysical theory. Later, he regained firm ground agreeing that it is genuine science (Ruse 2009).

the popular level, this was something that moved the discussion forward dramatically. If anything does, this qualifies as revolutionary science, showing the way to normal science. Remember, we have paradigm status "if achievement was sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity." This is a precise fit for James W. Tutt. Rather than putting everything down to God, in the fashion of earlier writers on the topic – "no study affords a fairer opportunity of leading the young mind by a natural and pleasing path to the great truths of Religion, and of impressing it with the liveliest ideas of the power, wisdom, and goodness of the Creator" (Kirby and Spence 1815–1828, xvi) – he used selection to explain industrial melanism. Remember also that "like the choice between competing political institutions, that between competing paradigms proves to be a choice between incompatible modes of community life." Thomas Hardy writing "Hap"! Darwinism scores at both the professional and the popular levels. Let us have no further silliness about things being non-Darwinian or non-existent.

What however of the more central option, that although Darwin did offer a paradigm so also did others and these others were more important than Darwin? No one is going to deny that there were these other options, in the Anglophone world probably most importantly Herbert Spencer's version of Lamarckism, which not only involved the inheritance of acquired characteristics produced in response to population pressures, but also a form of organicism where the state is seen as a living entity. Everyone notes the organicist nature of George Eliot's great novel *Middlemarch*, and although Henry James put it all down to Darwin and Huxley, it seems as plausible that it showed chiefly the influence of her great friend Herbert Spencer (Ruse 2017a). This said, apart from the fact that many of these ideas were embraced by Darwin – he was ever a Lamarckian – at the level of professional science it is not clear that people got much in the way of normal science out of the potpourri of half-baked ideas purveyed by Spencer and others. They simply weren't true! At the level of popular science, again and again one senses that, in reaction to the blind purposelessness of Darwinian selection, people are turning to other forms of evolution, almost inevitably guided forms of evolution (Ruse 2017b). Whether professional or popular, that certainly seems to have been true of Asa Gray, who wanted desperately to find some form of guided theistic evolution that would again make real the safe and secure world of Christianity. Darwin provided the paradigm. It was just that it scared many people!

Darwin's Debts

So, Kuhn is right here. There was a revolution and it is rightly called Darwinian. However, the story is shaggier and some respects not very Kuhnian. He speaks of "incommensurability" – meaning different worlds, different modes of thinking. Now you see a rabbit. Now you see a duck. This is just not true. With adaptation, we have already seen the transfer across the pre- and post-*Origin* divide of a major shared problem. This is but the tip of an iceberg. Darwin was a great revolutionary. He was no rebel (Ruse and Richards 2016). Like a kaleidoscope, he picked up the pieces and made a new picture. He was an upper-middle-class Englishman doing very well out of society. Why would he reject it? He didn't. He just reorganized it. No new worlds here, especially when it came to Anglican theology. Darwinian evolutionary theory is its bastard offspring. This is no great surprise. Darwin was raised an Anglican, probably at the evangelical end of things given the influence of his older sisters and the family hatred of slavery. He went to an Anglican private high school (public school). Finally, after a couple of years in Edinburgh, Darwin went to that bastion of Anglicanism, Cambridge University, where his teachers and mentors were all priests, a career that (until the *Beagle* voyage) Darwin intended for himself.

Family and schooling show. The struggle for existence is taken from the Anglican priest Thomas Robert Malthus. This cleric-cum-political-economist worried about population numbers but saw the struggle in a natural theological light as the way that – rather than spend our days drinking and wenching and simply adding to the world's problems – God had arranged that we humans would work for a living and show restraint (Mayhew 2014). Selection came straight out of the barnyard, or (thanks to Sebright) from the mountains around the farm. "I am the good shepherd; the good shepherd lays down His life for the sheep" (John 10:11). The good shepherd who also works to keep up his stock to the highest levels. Adaptation was known to all, but above all it was, thanks particularly to that indefatigable textbook writer Archdeacon William Paley, another gift of Anglican natural theology. "As far as the examination of the instrument goes, there is precisely the same proof that the eye was made for vision, as there is that the telescope was made for assisting it" (Paley 1802, 18). The division of labor, so crucial for speciation – better to focus on one life strategy rather than try to win them all – is right out of Adam Smith (1776). Who ensures that individual self-interest benefits us all? The Invisible Hand. The tree of life needs no introduction. "And out of the ground made the LORD God to grow every tree that is pleasant to the sight, and good for food; the tree of life also in the midst of the garden, and the tree of knowledge of good and evil" (Genesis 2:9). The whole package is wrapped up with the Anglican God,

good Englishman that He is, deciding in the ways of industrialists to do it all through the machine of evolution, unbroken law, than by hand, miraculously. Shades of those Lancashire cotton mills.

None of this is Kuhnian. The picture is new, but the elements are not. And things only get worse when you start adding in other factors like the already-known facts about paleontology, biogeography, systematics – think Linnaeus – and anatomy and embryology. What of the isomorphisms made so much of by Owen and others? These are a natural consequence of evolution, showing shared ancestry. Nothing very Kuhnian about any of this.

Metaphor

Let us not end on a down note about Thomas Kuhn. In his later writings, Kuhn (1993) made much of the notion of metaphor, arguing that in respects paradigms are metaphors. One can see easily why he would think this. Metaphors, like paradigms, talk about reality and yet in important respects – Kant-like – are reflections of human thinking. "The quarter moon, like a light skiff, / floats out of the mist-remnants / Of last night's hard rain." Technically an analogy rather than a metaphor, but you see the point. The moon is not a boat, it is not floating in anything, and certainly not in the mist. But the moon in its sickle form is a bit like a skiff, and it does move across the heavens as if floating, and the mist down here does give the impression that the moon is coming out through this mist. Reality and interpretation. Anyone who has worked on Darwin's thinking has to be struck sympathetically. Think of the metaphors. Struggle for existence, natural selection, design and adaptation, division of labor, tree of life. One keeps going. Darwin was the beginning of a tradition. Adaptive landscape, arms race, selfish gene, SFS – the interpretation of the last of these being left as an exercise for the reader, although as hints the first word is "sneaky" and the last "strategy."

Darwin's theory is a product of its time. Britain, at its height, in the nineteenth century. One is led to wonder, if the time and place had been different, whether one would have had the theory. I don't mean a different theory like Creationism – that's wrong – but rather a different way of conceptualizing things. Had we stayed with Athens and not turned to Jerusalem, would we even ask questions about origins? Aristotle got on well enough without doing so. If the industrial revolution had not brought on a population explosion, would we have had the Malthusian drive? Prince Petr Kropotkin, the Russian anarchist, was also a keen and informed biologist. In preindustrial Russia, the struggle was against the environment, not against other people. This is reflected in Kropotkin's (1902) take on evolution.

> As to various species of mice (Mus sylvaticus, Arvicola arvalis, and A. agrestis), the same author [Dr Altum] gives a long list of their enemies, but he remarks: "However, the most terrible enemies of mice are not other animals, but such sudden changes of weather as occur almost every year." Alternations of frost and warm weather destroy them in numberless quantities; "one single sudden change can reduce thousands of mice to the number of a few individuals." On the other side, a warm winter, or a winter which gradually steps in, make them multiply in menacing proportions, notwithstanding every enemy; such was the case in 1876 and 1877. Competition, in the case of mice, thus appears a quite trifling factor when compared with weather. Other facts to the same effect are also given as regards squirrels. (Kropotkin 1902, 36–37)

This led to Kropotkin's famous notion of "mutual aid" where organisms supposedly have a biological urge and need to help others. This is quite alien to the Adam Smith, proto-selfish-gene view of the author of the *Origin*. Organisms help themselves. Benefits to others come secondarily. "As many more individuals of each species are born than can possibly survive; and as, consequently, there is a frequently recurring struggle for existence, it follows that any being, if it vary however slightly in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be *naturally selected*" (Darwin 1859, 5). "Profitable to itself"! Not much about the good of others here.

This kind of thinking – what is known today as "individual selection" thinking as opposed to "group selection" thinking – completely underlies Darwin's discussion in the *Origin* where he discusses the sterility of hybrids (Ruse 1980). It would be so simple to argue that mules are sterile because it is of advantage to their parent species. Hybrids are literally neither fish nor fowl and – as Cuvier insisted – have a mélange of features that simply didn't function that well. You don't want fertile offspring like that. Darwin protested that, whatever the needs and benefits of the parent species, once born, it was in the interests of the parents to have the offspring fertile. So, for all that Wallace – who as a good socialist always favored group-type arguments – protested that this gave a handle to critics, Darwin put down the sterility simply to accident. Later, in the first edition of the *Descent*, Darwin argued that sex ratios tend to equality, because the individual interests of parents mean that they will favor the rarer sex and thus bring on selection, increasing the numbers of that sex. This, despite the fact that, from a group perspective, you might get along better with only a few members of one sex. A species of mainly mothers with a few studs would be ideal.

In important respects, Kuhn is right. Science – Darwinian science – is anything but telling it like it is. In Darwin's case, it is seeing the world through the eyes of an Anglican-trained industrialist – rather than a British socialist or

a Russian aristocrat. However, it is not pure idealism, just made up. There is no agreement with the sociologist of science who claimed provocatively that we create science rather than discover it: "The natural world has a small or non-existent role in the construction of scientific knowledge" (Collins 1981, 3). This is nonsense. Rather, as hinted earlier, one has a kind of neo-Kantian position where the world is structured and understood through mind-given elements. Neo-Kantian in that, unlike Kant who thought there was only one possible mind-given structure, the mind's elements are functions of the culture and the society of the day. Note that although the theory of truth embraced here is the coherence theory – get things to hang together – this does not preclude correspondence talk within the system. "Genes are selfish" is true because genes are selfish. Others, like Wallace, would not agree that "genes are selfish." Their world is not seen this way.

Epistemic Values

The position is not now one of rank relativism. No one is saying that anything goes. Creationism is wrong, whatever the culture or society. Nevertheless, one might well have rival positions with arguments in favor of both. One thinks of the eighteenth-century squabbles between Cartesians, who abhorred action at a distance, and Newtonians, who promoted the predictive successes of their system. This was more than "just the facts," yet hardly rank relativism or giving comfort to systems such as Creationism. Analogously, one might say that in evolutionary circles one has ongoing rival paradigms to this day – form versus function. Kuhn wins after all? Not really. We have a Darwinian *revolution*, and yet, in respects, these paradigms both go across the Darwinian divide! Form is the paradigm that stresses structure, and in biology it translates out as the problem of the similarities – isomorphisms – between organisms of quite different types. We have seen it in a non-evolutionary form in the early Owen, where vertebrates – humans, horses, birds, marine mammals – have shared skeletal forms, for all that they have very different purposes. Function is the paradigm that stresses adaptation, and in biology it focuses on what the non-evolutionist Georges Cuvier called the "conditions of existence." The arm for grasping, the forelimb for running, the wing for flying, the flipper for swimming.

Across the evolutionary divide, in formal thinking we have probably the later Owen (1866), interpreting isomorphisms – that he christened homologies – as evidence of shared ancestors, formerly understood as Platonic forms. More recently, we have people like (my fellow expert witness) the late Stephen Jay Gould, who always had a yearning for a theory that makes form – homology – at least the equal to if not the superior to adaptationism.

> An adaptationist programme has dominated evolutionary thought in England and the United States during the past forty years. It is based on faith in the power of natural selection as an optimizing agent. It proceeds by breaking an organism into unitary "traits" and proposing an adaptive story for each considered separately. Trade-offs among competing selective demands exert the only brake upon perfection; nonoptimality is thereby rendered as a result of adaptation as well. We criticize this approach and attempt to reassert a competing notion (long popular in continental Europe) that organisms must be analyzed as integrated wholes, with baupläne so constrained by phyletic heritage, pathways of development, and general architecture that the constraints themselves become more interesting and more important in delimiting pathways of change than the selective force that may mediate change when it occurs. (Gould and Lewontin 1979, 581)

In the functionalist camp, we obviously have Darwin and all of his followers. Although note another complexity, namely that people slip in and out of the different paradigms! Gould certainly did not want to deny adaptation and function. Just make it less important than form. Going the other way, this is true also of Darwin. His barnacle work was almost entirely formalist. In the *Origin*, he wanted to recognize form, even as he downplayed it.

By this time, if they can go across the Darwinian Revolution and people can have a foot in both camps, you may be wondering if it makes sense still to talk in terms of Kuhnian "paradigms." It's your choice really, but I would defend it. We are still recognizing the central Kuhnian truth that scientific theories are more than brute empirical reports, but in a neo-Kantian sense are formed from prior commitments or visions or paradigms. This is hugely important, at both the epistemological and sociological levels. You may have a foot in both formalist and functionalist camps or paradigms, but it doesn't mean that the tensions don't emerge. Thus, the eminent, English, Darwinian evolutionist, ardent functionalist John Maynard Smith on the subject of the American formalist Stephen Jay Gould.

> Gould occupies a rather curious position, particularly on his side of the Atlantic. Because of the excellence of his essays, he has come to be seen by non-biologists as the preeminent evolutionary theorist. In contrast, the evolutionary biologists with whom I have discussed his work tend to see him as a man whose ideas are so confused as to be hardly worth bothering with, but as one who should not be publicly criticized because he is at least on our side against the creationists. All this would not matter, were it not that he is giving non-biologists a largely false picture of the state of evolutionary theory. (Maynard Smith 1995, 46)

Kuhn prepares you for this in a way that, once again, Hempel and Nagel never did.

Nevertheless, you may worry that we are getting close to saying that Darwin's theory is one among a number of virtually infinite ways of conceptualizing organisms and their histories, and even though the Creationists cannot claim a place of their own, they can continue their attack on the preeminence of Darwinian thinking. Against this, philosopher of science Ernan McMullin (1983) thought one can see some definite marks of Progress if one seizes on the notion of an epistemic value. This is expressed as a rule about how you are to proceed (in science) to get closer to the truth, a better understanding of reality. Epistemic values are things that you prize about good science (Ruse 1996). They include: Internal coherence – the parts of a theory must hang together. When it seemed that one would have to describe an electron as both a particle and a wave, Heisenberg's Uncertainty Principle was introduced, ruling out awkward questions. External consistency – a theory must not conflict with other theories. When Darwin's theory seemed to conflict with physics, something had to give. Predictive ability – saying what will happen. This was the great strength of Newton's theory of gravitational attraction. Fertility – yielding new questions in new areas. The DNA model, the double helix, led to new insights all over the field. Unifying power – what Whewell called a consilience of inductions. Newton brought the heavens and the earth under the same causal forces. Somewhat controversially, simplicity – a sense of economy and elegance. This is crucial in mathematics, but important in science too. Kuhn makes this point about paradigms. Sometimes they are so elegant, so simple, you feel they must be true. The double helix again. As soon as people saw it, they knew it must be the answer. These are enough examples of such values, although there are other contenders – Popper's notion of falsifiability is one. Perhaps it is better regarded as an amalgam of values already introduced – prediction particularly.

Epistemic values are to be distinguished from social and cultural values, like white over black, Protestant over Catholic, boys over girls. McMullin argues that, in the early phases of a theory's (or paradigm's) history, cultural values play a big role. Freud favors males over females. Then as the theory (or paradigm) matures, the epistemic values take over and kick out the cultural values. Claims like males are better than females simply led to bad or no predictions and had to go. Individual scientists might be male chauvinist pigs, but such views had no place in the mature science. Hence, you recognize that the constructivists are right in seeing values in (early) science, but you see also that conventional theorists are right in thinking that the aim of science is to capture a real world. This goal, thanks to epistemic values, dominates successful science.

Is the Darwinian Revolution the exemplar of a McMullin-type development of science? The key cultural notion is that of Progress – of medicine, education, economics, and more, getting better through human effort. Thus understood, Progress is a good thing. The early evolutionists took this notion and read it right into nature – monad to man. Culture dominates. Evolutionary theory was made, not discovered. Then the epistemic values took over. First came natural selection, with all of the epistemic power of predictive fertility and so forth. Yet, thoroughly relativistic. What wins, wins. As Darwin said, scribbling on the flyleaf of his copy of *Vestiges*, there is no higher or lower. Then came Mendelian genetics, which insists (what Darwin always insisted) that the origination of new variation, mutation, is random, in the sense of not occurring according to need. Again, anti-progress but cherished for its epistemic virtues. Hence, we come down to the present and you search in vain in the professional journals like *American Naturalist* and *Evolution* for mention of P/progress, social or biological. We have an epistemically powerful theory. We are discovering, not creating.

There is an obvious alternative hypothesis. Perhaps culture is as prominent in today's evolutionary biology as it ever was. It is just that it has changed! From an eighteenth-century enthusiasm for cultural Progress, and hence by analogy to biological progress, we have now a twenty-first-century repudiation of cultural Progress and hence by analogy of biological progress. When you think of the Middle East and of drugs and of global warming, who today dares speak of cultural Progress? No wonder that we cannot find the biological equivalent in the journals of today. Plausible, but as Thomas Henry Huxley once said about one of Herbert Spencer's effusions, a beautiful hypothesis slain by an ugly fact. The truth is that Progress/progress is overwhelmingly popular among today's Darwinians. On the one side of the Atlantic, Richard Dawkins: "Directionalist common sense surely wins on the very long time scale: once there was only blue-green slime and now there are sharp-eyed metazoa" (Dawkins and Krebs 1979, 508). On the other side of the Atlantic, Edward O. Wilson: "The overall average across the history of life has moved from the simple and few to the more complex and numerous. During the past billion years, animals as a whole evolved upward in body size, feeding and defensive techniques, brain and behavioral complexity, social organization, and precision of environmental control – in each case farther from the nonliving state than their simpler antecedents did" (Wilson 1992, 187). Adding: "Progress, then, is a property of the evolution of life as a whole by almost any conceivable intuitive standard, including the acquisition of goals and intentions in the behavior of animals."

I suspect a major reason for the enthusiasm for biological progress is that science is one of the few places where one does see cultural Progress, at least in the eyes of the practitioners. There may not be absolute Progress; but, even in Kuhn's weaker sense, Darwin is better than Cuvier and today's evolutionists better than Darwin. Whatever the reasons, progress is there and has been there in Darwinism starting with Darwin himself. He was even more chauvinistic about P/progress than Wilson. "The more civilised so-called Caucasian races have beaten the Turkish hollow in the struggle for existence. Looking to the world at no very distant date, what an endless number of the lower races will have been eliminated by the higher civilised races throughout the world" (Letter 13230, Darwin Correspondence Project, to William Graham July 3, 1881). Yet Darwin and his successors wanted to be professional and they shared McMullin's worry about values in science. The obvious move therefore was to make progress epistemically respectable. Darwin plunged in, coming up with a proto-version of "arms races," where lines compete and improvement obtains. This was added (in 1861) to the third edition of the *Origin*.

> If we look at the differentiation and specialisation of the several organs of each being when adult (and this will include the advancement of the brain for intellectual purposes) as the best standard of highness of organisation, natural selection clearly leads towards highness; for all physiologists admit that the specialisation of organs, inasmuch as they perform in this state their functions better, is an advantage to each being; and hence the accumulation of variations tending towards specialisation is within the scope of natural selection. (Darwin 1861, 134)

Today Richard Dawkins (1986) has put this in terms of modern military advances, ending with electronics. Humans have won because they have the biggest onboard computers. Unfortunately, this suggestion, like others that have been proffered, is inadequate (Ruse 2017b). As the paleontologist J. John (Jack) Sepkoski Jr. points out colorfully, no such naturalistic solutions explaining absolute progress could work. In the Darwinian world, there simply is no such absolute biological progress. "I see intelligence as just one of a variety of adaptations among tetrapods for survival. Running fast in a herd while being as dumb as shit, I think, is a very good adaptation for survival" (Ruse 1996, 486). Arms races don't necessarily lead to complexity and computers. Sometimes "keep it simple, stupid" is what works. Cow power runs supreme.

The truth is that everyone believes in progress and likes it, and then looks for ways to make it respectable. Or not. Some biologists are remarkably relaxed about biological progress. Wilson is one. He just thinks it happens. In this,

Wilson stands in the tradition of Herbert Spencer. Spencer in turn goes back to the German Romantics, especially Friedrich Schelling (of whom, I am sure, Wilson has never heard). There is a kind of upwards force driving evolution. Some evolutionists, particularly those like the late nineteenth-century American paleontologist Henry Fairfield Osborne (1896), have been quite open in their enthusiasm for such "orthogenetic" forces. Later, particularly under the influence of Henri Bergson (1907), vital forces have been thought to play a role. This was certainly the thinking of the French Jesuit paleontologist, Pierre Teilhard de Chardin (1955), and probably of the man who became the president of the British Teilhard Society, the biologist grandson of T. H. Huxley, Julian Huxley (Ruse 1996). Possibly also of the man who became the president of the American Teilhard Society, the Russian-born population geneticist, Theodosius Dobzhansky (Greene and Ruse 1996).

So why then is talk of progress absent in modern professional evolutionary theory? Because, around 1940, when modern evolutionary theory – neo-Darwinism – was getting underway, the evolutionists – P/progressivists to a person – saw that so obviously a value-laden notion at the center of their science was incompatible with the standards of professional science – epistemic all the way. Desirous of university posts and students and grants, deliberately they set about removing talk of progress from their work! Ernst Mayr, first editor of the very professionally intended new journal *Evolution*, was explicit to his would-be contributors. "It has so far been the editorial policy of *Evolution* to present concrete facts in every paper followed by the conclusions to be drawn from these facts. This policy was adopted deliberately because the prestige of evolutionary research has suffered in the past because of too much philosophy and speculation."

Philosophy and speculation? You can't get much worse than that! In other letters, Mayr was explicit that progress was the problem. "It may be well to abstain from the use of the word "orthogenesis" (harmless as it is, in my opinion), since so many geneticists seem to be of the opinion that the use of the term implies some supernatural force" (Ruse 1996, 447). Epistemic values are being promoted and cultural values cast out because of the cultural scientific value of respect and prestige from one's fellow professionals and the outside world. You might say that, whatever the reasons, McMullin's ideal of an epistemic, culture-free science is being realized. This is true. Like Lenin's closed train that took him across Germany to Russia, who cares so long as you get the desired results? Notice however that you are shaping what you are prepared to call professional, mature science. If not in the science as such, then implicitly the value of being a professional is at work on your science. To bring

the Darwinian Revolution to some kind of completion, you had to get onside with the right values. This is quite apart from the fact that, epistemic or not, you still work with the metaphors of your culture. Unlike Malthus, someone might think the population explosion and consequent struggle absolutely awful – but still use the ideas in one's science. The same with the division of labor. So a counterproductive boredom does not set in, many firms these days see the virtues in workers having a range of tasks. For all this, in biology, one could and does use the division of labor in the sense of the harshest factory owner. Hence, in taking up his theory, we are not necessarily endorsing Darwin's cultural values – Charles Darwin, the grandson of manufacturer Josiah Wedgwood, had little love of unions – but we are still reflecting Darwin's culture (Richards and Ruse 2016).

Evolution as Religion

From Darwin on, P/progress was a prominent part of the popular side to Darwinian thinking. People like Hardy may have despaired – although toward the end of his life even he got onboard with something he called "evolutionary meliorism" – but the general tempo was one of upwards, ever upwards. Just before the *Origin*, Spencer staked his claim and he never afterwards wavered.

> Now we propose in the first place to show, that this law of organic progress is the law of all progress. Whether it be in the development of the Earth, in the development of Life upon its surface, in the development of Society, of Government, of Manufactures, of Commerce, of Language, Literature, Science, Art, this same evolution of the simple into the complex, through successive differentiations, hold throughout. From the earliest traceable cosmical changes down to the latest results of civilization, we shall find that the transformation of the homogeneous into the heterogeneous is that in which Progress essentially consists. (Spencer 1857, 2–3)

Today, you get evolutionists like the paleontologist George Gaylord Simpson writing professional books, *Tempo and Mode in Evolution* (1944), with no mention of P/progress; then popular books, *The Meaning of Evolution* (1949), that are P/progress all of the way; finally, back to professional books, *The Major Features of Evolution* (1953), where P/progress is again absent. It continues. Wilson's fellow Harvard professor, the evolutionary linguist Stephen Pinker (2011, 2018), is enthusiastic about P/progress, writing one popular book after another on the theme. There are naysayers. Toward the end of his life, Thomas Henry Huxley (1893), for all that he talked of us taking "the headship of the sentient world," worried that it was all a charade. More recently, Stephen Jay Gould argued strongly against biological progress. "A noxious, culturally embedded, untestable, nonoperational, intractable idea

that must be replaced if we wish to understand the patterns of history" (Gould 1988, 319). Parenthetically, this was a stand as value-laden as that of Wilson and Pinker. At one point, like almost everyone else, Gould (1977) endorsed progress. Then he saw progress as being bound up with racial views about human nature – four legs good, two legs better, Jews good, gentiles better. His stance on adaptationism – which he saw as part of the Darwinian picture of progress – was part of this moral drive. To achieve Progress, in which Gould believed, we must deny progress!

We had – we have – a popular science of Darwinian evolutionary biology that is value impregnated, with progress being (as one might say) its backbone. Does this popular science ever, sometimes, often, become something more? Does it take on the role of a secular religion – or, if you like, does it offer a secular, religious perspective? Evolutionists have said it does. From a letter written by Thomas Henry Huxley, before the *Origin*: "Few see it but I believe we are on the eve of a new Reformation and if I have a wish to live thirty years, it is that I may see the foot of Science on the necks of her Enemies . . . But the new religion will not be a worship of the intellect alone" (quoted by Desmond 1997, 253). In the spirit of Darwin, his grandson Julian Huxley wrote that "the pursuit of the religious life is seen to resemble the pursuit of a scientific truth or artistic expression, as the highest of human activities" (Huxley 1927, 53–54). Today, Edward O. Wilson tells us: "The evolutionary epic is mythology in the sense that the laws it adduces here and now are believed but can never be definitively proved to form a cause-and-effect continuum from physics to the social sciences, from this world to all other worlds in the visible universe, and backward through time to the beginning of the universe" (Wilson 1978, 192). No wonder that: "Theology is not likely to survive as an independent intellectual discipline."

I don't think Darwinism has to be a religion. Going to a great institution of natural history does not have to be a religious experience. Although it is interesting how often it points that way, intentionally. Toward the end of the nineteenth century, natural history museums were being founded with the express purpose of offering an alternative. Instead of going (with the family) to the Christian church on a Sunday morning and imbibing the values of that religion, one should go (with the family) to the museum on a Sunday afternoon and – looking at those wonderful displays of fossils – imbibe the story of progress and of Progress. If you doubt what I am saying, on visiting Toronto, look at the exterior of the Royal Ontario Museum (founded just before the First World War). It is an exact facsimile of the Norman architecture of Durham Cathedral.

The notion of a religion is notoriously difficult to define, but, even if not possessed by all, prominent features are beliefs in a deity, a story of origins,

a special place for humans, an ethical code, discussions about the significances of race and sex, hopes for the future. With gusto, Darwinians set about answering these questions, and they still do (Ruse 2017a, 2018). We have seen Hardy on the subject of God. Richard Dawkins is still at it, although he wants to get rid of God entirely and good riddance. "The God of the Old Testament is arguably the most unpleasant character in all fiction: jealous and proud of it; a petty, unjust, unforgiving control-freak; a vindictive, bloodthirsty ethnic cleanser; a misogynistic, homophobic, racist, infanticidal, genocidal, filicidal, pestilential, megalomaniacal, sadomasochistic, capriciously malevolent bully" (Dawkins 2006, 1). This is the voice of an Old Testament prophet.

Evolution is all about origins, and progress is all about us humans having as big a status in the new order of things as we had in the older Christian order of things. From Darwin on there has been worry about morality. Remember how "throughout the world tribes have supplanted other tribes" and how "morality is one element in their success." We have already encountered race and sex – those inadequate Turks and those flighty girls who prefer dancers to fossil hunters. To be fair, Darwinians have thought as seriously about sex as have Christians. That good Victorian Charles Darwin may have decried calmly that "Man is more courageous, pugnacious, and energetic than woman, and has a more inventive genius." Apart from the fact that Darwin led a domestic life totally dominated by that benevolent despot, his wife Emma, Constance Naden saw things were much more balanced and writers have continued to see that. In the Old Testament, the Jews worried themselves silly about making the right matches – think of the story of Ruth and of how Boaz had to defer to established customs to marry her. No simple passion. Edgar Rice Burroughs, creator of Tarzan, was an enthusiastic Darwinian, and when it came to marrying up Tarzan and Jane, he saw that in the world of the *Descent of Man*, things are complex. No simple passion. In the first novel of the series, *Tarzan of the Apes*, Jane suppresses "the psychological appeal of the primeval man to the primeval woman in her nature" and, following the Darwinian strategy of looking after Number One, makes the calculated decision to marry the apparent Lord Greystoke (William Cecil Clayton) instead of the (unacknowledged) true Lord Greystoke (Tarzan).

> Did not her best judgment point to this young English nobleman, whose love she knew to be of the sort a civilized woman should crave, as the logical mate for such as herself?
>
> Could she love Clayton? She could see no reason why she could not. Jane was not coldly calculating by nature, but training, environment and heredity had all combined to teach her to reason even in matters of the heart. (Burroughs [1912] 2008, 340)

One is glad to say, for those whose lives would be sunshine-deprived without the twenty-five sequels, this engagement does not outlast the next installment in the series.

What of the future? Some, like Huxley's student, the novelist H. G. Wells, took a rather gloomy view of things. In *The Time Machine*, the traveler goes as far as he dare into the future. "The sky was absolutely black." But then. Was it just a rock? Was it an illusion? "As I stood sick and confused I saw again the moving thing upon the shoal— there was no mistake now that it was a moving thing— against the red water of the sea. It was a round thing, the size of a football perhaps, or, it may be, bigger, and tentacles trailed down from it; it seemed black against the weltering blood-red water, and it was hopping fitfully about" (Wells 1895, 86). He has had enough and comes back home. Others were and are more optimistic. In his Pulitzer Prize winning *On Human Nature* (1978), Edward O. Wilson – who we have just seen explicitly wanting an evolutionary humanism to replace traditional Christianity – talks happily of a good future, so long as we take up an earlier suggestion. Philosophy is to be taken out of the hands of philosophers and "biologicized" (Wilson 1975, 1). More recently, at the age of 86, he has written: "Laid before us are new options scarcely dreamed of in earlier ages" (Wilson 2014). A Promised Land, indeed.

We now know a lot about the history of Creationism – of how it came in the mid-nineteenth century out of the Seventh-day Adventist movement, how it became a refuge and hope for the South after the defeat of the Civil War, how it throve in the late twentieth century because of worries about the Cold War, and more (Numbers 2006). We know also that evolution – Darwinian evolution – got caught up in this (Larson 1997). This was not truly because of issues about strict literalism. No one, for instance, takes literally the tale of the Whore of Babylon. She is always the Pope or the Catholic Church as a whole or Saladin or, today, other threatening Muslims. For me, she has always been my late headmaster. Darwinian evolution was more a symbol of the hated modernism, the philosophy/religion of the oppressive forces of the North. Darwinism stood/stands for the anti-Christ and that is enough. In Kuhnian terms, I suspect that those of us who would move on to end this controversy have on our hands more of a problem than a puzzle. However, recognizing how Darwinians so often make a religion out of their science certainly goes some considerable way to explaining the often-bitter nature of the debate between Darwinians and the extreme evangelicals. Think the Thirty Years War. Think Protestants and Catholics in Northern Ireland. Think the Muslims and Hindus and the partition of India. Think of much of the Middle East today. I am not sure how very Kuhnian any of this is. It seems off the scale compared to the discussions of

The Structure of Scientific Revolutions. Whatever. Kuhn prepares the way for how Darwinism takes off from reason and evidence and plunges us into emotion and conflict. The Darwinian Revolution is no long-forgotten story of the past.

4 Philosophical Epilogue

Summing Up

Let me stress what I have and have not been arguing, particularly toward the end of the last section. First, whether or not you consider the pre-*Origin* period as pre-paradigmatic, I see the Darwinian Revolution as having brought into being a fully functioning, professional area of science, paradigm if you will. In the modern version – neo-Darwinism or the synthetic theory – this asserts that natural selection is the main mechanism of change operating in a world of Mendelian (today molecular) genetics. It is a good strong theory, one that explains a great deal. As Theodosius Dobzhansky used to say: "Nothing in biology makes sense except in the light of evolution." It is teleological, allowing final-cause explanations, in a way barred in the physical sciences. I take it that this is the nature of the beast, an incredibly powerful and important method of understanding, and in no way a fault or a mark of the second class.

Given my high regard for metaphor, you will not be surprised to learn that I think this teleology is all bound up with metaphor. Organisms are design-like in a way that rocks are not. I stress that the final causes of biology come into being because of efficient causes and are in no way rivals. The use of metaphor in itself is no sign of weakness, nor is the fact that one science demands a metaphor that another does not. My cairn terriers are monkeys; my wife's whippets are not. I see this picture through neo-Kantian spectacles. This means we directed to a coherence rather than a correspondence theory of truth, where culture plays a role, where values about the very nature of desirable science play a role, and where the possibility of alternative positions must be allowed. Perhaps they already exist. What is important is that none of this is peculiar to Darwinism. It could and almost certainly does apply to other areas of science as well.

Second, complementing the professional science, there is a popular Darwinian science, based on the professional science, but – along with simplifications of the technical mathematical studies – full of cultural values, most notably thoughts of cultural Progress and biological progress, upwards climb to human beings. This is not bad professional science. It is good popular science.

It has its aims and standards and it is by these that it should be judged. Works like *The Selfish Gene* by Richard Dawkins (1976), and *On Human Nature* by Edward O. Wilson (1978) are magnificent examples of the genre. As is *Wonderful Life* by Stephen Jay Gould (1989), for all that he flips the other way on progress – in order to achieve Progress! What is true, whether you applaud it or regret it, is that this popular side to Darwinian thinking segues easily and often into a kind of secular religion. It does not have to – Gould shows that we can do the popular work without progress – but, very often, it does. I suspect that this accounts for much of the tension between Darwinism and so many Christians, especially those at the more evangelical end of the spectrum.

Third, and here we do have a new topic, where are we today? Is the Darwinian Revolution now over? No one thinks that all the professional scientific work has been done – there are many more organisms to be studied – but we are now in the world of normal science. I say this acknowledging that there are those (scientists) who are not comfortable with pure Darwinism (Ruse 2006). This applies particularly to those like Gould who seek a more formalist and less functionalist biology, and extends to those (often but not necessarily the same people) who want a more "holistic" perspective on change rather than the supposed "reductionistic" view of Darwinians – meaning here breaking things down into smaller parts and then trying to explain upwards (Goodwin 2001). Acknowledging and allowing that there are these minority positions, that they will probably never vanish – because in respects the differences are more metaphysical than purely scientific – and even accepting that things could change and one of them could rise in general importance and acceptance, is not to say that Darwinians need spend time worrying or distracted from the work they have to do.

Darwinism and Philosophy

Immanuel Kant (1788) said: "Two things fill the mind with ever-increasing wonder and awe, the more often and the more intensely the mind of thought is drawn to them: the starry heavens above me and the moral law within me." Epistemology, what can I know, and ethics, what shall I do. Darwin was not a professional philosopher but, as an educated Englishman, he knew philosophy, and he had no doubt that his theorizing had implications in those directions. Why not? One would think it blindingly obvious that, if we humans are the products of a long, slow, natural process of development from lower organisms, rather than made miraculously in the image of a good God, then this has implications for both epistemology and ethics (Ruse 1986, 2009).

In the realm of epistemology, sometimes Darwin played with the notion that ideas can function like organisms, being in a struggle for supremacy and the successful being selected. In the *Descent*, he argued this for language.

> As Max Müller has well remarked:—"A struggle for life is constantly going on amongst the words and grammatical forms in each language. The better, the shorter, the easier forms are constantly gaining the upper hand, and they owe their success to their own inherent virtue." To these more important causes of the survival of certain words, mere novelty may, I think, be added; for there is in the mind of man a strong love for slight changes in all things. The survival or preservation of certain favoured words in the struggle for existence is natural selection. (1, 70)

Sometimes, more literally, Darwin argued that our minds have been shaped by evolution and this makes us think in the ways that we do: "Plato Erasmus says in Phaedo that our necessary ideas arise from the preexistence of the soul, are not derivable from experience.— read monkeys for preexistence —" (Barret et al 1987, M 128). This comment comes from an early notebook and was made in the very month that Darwin was homing in on selection as a mechanism of change. ("Erasmus" was Charles Darwin's older brother, named after their grandfather.)

In ethics, one has a similar division. There is the more historical version where one sees improvement over time. Darwin thought this of the English and the Turks! Herbert Spencer is the person best known for this kind of argument. "Ethics has for its subject-matter, that form which universal conduct assumes during the last stages of its evolution" (Spencer 1879, 21). Then there is the more literal version. This sees our moral sense as having evolved through selection – a view to which we have seen Darwin subscribes completely – and then tries to extract philosophical juice from this. Most likely it seeks out the implications for justification, what philosophers call "meta-ethics," and – given the various possibilities to which selection points – as likely is drawn to some kind of moral non-realism. Dramatically, also in the *Descent*, Darwin wrote:

> If, for instance, to take an extreme case, men were reared under precisely the same conditions as hive-bees, there can hardly be a doubt that our unmarried females would, like the worker-bees, think it a sacred duty to kill their brothers, and mothers would strive to kill their fertile daughters; and no one would think of interfering. Nevertheless, the bee, or any other social animal, would in our supposed case gain, as it appears to me, some feeling of right and wrong, or a conscience. (1, 73)

It is not that everything is now totally relative. Morality must fit with selfish-gene thinking. It is just that there might be more than one way of skinning the moral cat.

In America one group of philosophers – the Pragmatists – ran fast and far with Darwinian theory (Weiner 1949). In epistemology, you would expect this, for essentially Pragmatism is saying that it is success that counts and makes for such truth as we have. Charles Sanders Peirce, the deepest thinker of the school, offered this explication. "Consider what effects, that might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object." He saw that this is Darwinian in essence. In the world of organisms: "Darwin, while unable to say what the operation of variation and natural selection in any individual case will be, demonstrates that in the long run they will, or would, adapt animals to their circumstances." Then, in the world of thought: "Logicality in regard to practical matters (if this be understood, not in the old sense, but as consisting in a wise union of security with fruitfulness of reasoning) is the most useful quality an animal can possess, and might, therefore, result from the action of natural selection . . . " (Peirce 1955, 8). Peirce was deeply influenced by German philosophy, and he would have seen the Darwinian claims about innate ideas or mind structures as more Kantian than Platonic. William James however pointed out that there is a big shift. For Kant, something like thinking causally is a necessary condition for rational thought. For Darwin, in epistemology as in ethics, one has moved from absolutes. In speaking of Pragmatism, James (1907) wrote: "Superficially this sounds like Kant's view; but between categories fulminated before nature began, and categories gradually forming themselves in nature's presence, the whole chasm between rationalism and empiricism yawns" (249).

In the thinking of Dewey, who was concerned through his life with practical ethics, particularly in the realm of education, one sees deeply Darwinian strands. Generally, however, ethics was not a major concern of the early Pragmatists. A major reason for this lack of concern could have been unease about where such an inquiry would lead. In the late nineteenth century, popular in some circles – industrial and military – were (what have since been labeled) "social Darwinian" claims about the moral necessity of conflict. Peirce hated these supposed harsh social implications, winners taking all and losers getting nothing. By the end of the nineteenth century, he was celebrating what he took to be the decline of Darwinism, writing "the extraordinarily favorable reception it met with was plainly owing, in large measure, to its ideas being those toward which the age was favorably disposed, especially, because of the encouragement it gave to the greed-philosophy." Peirce was not alone here. Philosophers

in England were almost uniformly discouraging. John Stuart Mill allowed Darwin, but only as a hypothesis, not as something true. It was not part of his ethical thinking. The leading ethical philosopher Henry Sidgwick (1876) was violently opposed to thoughts of Darwinism having implications for either prescriptions or justifications.

The Analytic Rejection

In England at the beginning of the twentieth century, in both epistemology and ethics, this was a position that solidified (Cunningham 1996). Everyone was raised on a diet of Plato. Needing to produce philosopher kings to run the Empire, the *Republic* was the guidebook of Victorian education.[9] Faced with the Theory of Forms, Darwin's ideas had no chance at all. First Bertrand Russell, whose big aim (unsuccessful in the end) was to deduce mathematics from logic.

> I came to think of mathematics, not primarily as a tool for understanding and manipulating the sensible world, but as an abstract edifice subsisting in a Platonic heaven and only reaching the world of sense in an impure and degraded form. My general outlook, in the early years of this century, was profoundly ascetic. I disliked the real world and sought refuge in a timeless world, without change or decay or the will-o'-the-wisp of progress. (Russell 1959)

The consequence? "What biology has rendered probable is that the diverse species arose by adaptation from a less differentiated ancestry. This fact is in itself exceedingly interesting, but it is not the kind of fact from which philosophical consequences follow" (Russell 1914, 15). Complementing this, in ethics, there was the student of Sidgwick, G. E. Moore. In his *Principia Ethica*, he found the fount of morality in ethereal nonnatural properties. "I am pleased to believe that this is the most Platonic system of modern times." Little wonder that he boasted: "Evolution could hardly have been supposed to have any important bearing upon philosophy" (Moore 1903, 34).

If this were not enough, there was their protégé, the Austrian Ludwig Wittgenstein, sensitized during the Great War by exposure to harsh applications of Darwinism to matters of war and conflict. In his seminal *Tractatus,* he wrote: "Darwin's theory has no more to do with philosophy than any other hypothesis in natural science" (Wittgenstein 1922, 4.1122). Even in the middle of the

[9] Ten years after the end of the Raj (1947), it was still being taught to that end in English, private schools. At my good Christian institution, in the equivalent of Grade Twelve, it took over the slot reserved for Scripture.

twentieth century, when Darwinian theory combined selection with Mendelian genetics and all was moving forward confidently, he kept up the theme. "I have often thought that Darwin was wrong: his theory doesn't account for all this variety of species. It hasn't the necessary multiplicity" (Rhees 1981, 174). In and outside the kind of "analytic" philosophical approach that he and his fellows were formulating, Wittgenstein was not alone in this kind of thinking. Thomists and continental thinkers veered between indifference and outright hatred. Hannah Arendt (1976) wrote: "Underlying the Nazis' belief in race laws as the expression of the law of nature in man is Darwin's idea of man as the product of a natural development which does not necessarily stop with the present species of human beings" (161).

Anglophone philosophers simply ignored Darwin. *The Oxford Handbook of the History of Analytic Philosophy* is 1161 pages long. Darwin and his theory are nonsubjects. Of course, popping up during the century you do find some Darwinian ideas. Famously, the leading thinker, W. V. O. Quine, who always showed debts to Pragmatism, argued that Darwin gives insight into problems of induction. "There is some encouragement in Darwin. If people's innate spacing of qualities is a gene-linked trait, then the spacing that has made for the most successful inductions will have tended to predominate through natural selection. Creatures inveterately wrong in their inductions have a pathetic but praiseworthy tendency to die before reproducing their kind" (Quine 1969, 126). In the early 1950s, Quine and Kuhn met regularly thanks to the Society of Fellows at Harvard. Kuhn came by his Darwinism legitimately, for his disavowal of one true-for-all-time paradigm owes much to the views of Quine about the possibility of relative, rival modes of understanding. Interestingly, however, Quine did not much care for Kuhn's use of his thinking and his Harvard colleague, Hilary Putnam (1982), wrote explicitly against the possibility of using Darwin in epistemological questions.

The same kind of hesitancy can be found in moral philosophical thinking. In his seminal work *A Theory of Justice*, Quine's Harvard colleague, John Rawls, picked up on Darwinian thinking, using it as a causal explanation for his own version of the social contract theory.

> In arguing for the greater stability of the principles of justice I have assumed that certain psychological laws are true, or approximately so. I shall not pursue the question of stability beyond this point. We may note however that one might ask how it is that human beings have acquired a nature described by these psychological principles. The theory of evolution would suggest that it is the outcome of natural selection; the capacity for a sense of

> justice and the moral feelings is an adaptation of mankind to its place in nature. (Rawls 1971, 502–503)

However, Rawls then jumped sharply back into line when it came to philosophical issues. "These remarks are not intended as justifying reasons for the contract view" (504). This kind of help must be sought elsewhere.

These are the high points. We saw in the Prologue how today's analytic philosophers regard the relevance of Darwin's thinking to their discipline. Not only do they disparage evolution through natural selection, even those who dare speak favorably are castigated. In talking of the Darwinian explanation of the problem of induction, Jerry Fodor tells us that: "Quine was too subtle a philosopher to be fully satisfied by this explanation. He recognized that there was a circularity in it" (Fodor and Piattelli-Palmarini 2010, 166). Alvin Plantinga (1991) thinks that comparing Darwin's revolution with that of Copernicus is "an enormous exaggeration" (692). Thomas Nagel (2012) asserts: "It is prima facie highly implausible that life as we know it is the result of a sequence of physical accidents together with the mechanism of natural selection" (6). And so on and so forth – and forth and forth and forth.

Completing the Darwinian Revolution

"Westward look, the sky is bright." Perhaps Edward O. Wilson did have a point about the need to "biologicize" modern philosophy. Professional Darwinian evolutionists – primatologists, evolutionary psychologists, physical anthropologists, and others – looking at human thinking, its origins and its nature, are finding huge amounts about our reasoning and the thought processes behind our social attitudes. In parallel, in part stimulated by this empirical work, there are still some philosophers who are trying to use evolutionary biology to inform and ground their beliefs about matters epistemological and ethical (Ruse 2009; Ruse and Richards 2017). After initial denial, like Saul of Tarsus, l have long been an enthusiast (Ruse 1986; Ruse and Wilson 1985, 1986). From scorn and mocking, I have now got to the stage where I am being refuted in journals that would never accept anything written by me. So, let me end this *Element* positively. With respect to epistemology, analogies are analogies – like fire, good servants but bad masters. If someone finds it helpful to think of change as a Darwinian process, then who is to say other? However, the danger is that the metaphor can mean all things to all people. It has always struck me as incredible cheek that Kuhn, of all people, should appropriate Darwinism

to his own ends. The switch from one paradigm to another is about as non-evolutionary, non-Darwinian, as it is possible to image. Darwinian incommensurability, indeed! Another major problem with the Darwinian analogy is about the cultural equivalents to biological units in the evolutionary process. Richard Dawkins (1976) proposes that we talk of "memes" as the equivalent of genes. But what is a meme? Is it Figaro's aria in the first act of *The Marriage of Figaro*? The whole opera? All three Da Ponte operas? The questions come. The analogies become frail and translucent as soon as you start to push them.[10]

Taking Darwin literally, with the way we think influenced and constrained by evolutionary history, seems more promising. Proto-humans who saw two tigers go into a cave and one emerge and concluded – "Tigers still in cave? Just a theory not a fact!" – were destined to remain just what they are – proto. Some reasoning worked, some didn't. That is the beginning and end of it all. Like most professional philosophers, I am always uncertain about totally new ideas. Whitehead said, discerningly, that philosophy is a series of footnotes to Plato. For all that James properly cautioned us, Darwinian epistemology is very Kantian in spirit and mostly in practice (Lorenz 1941). Because of worries about the coherence of absolute reality – the *Ding an Sich* – probably more inclined to a pragmatic coherence than correspondence thinking. This, incidentally, speaks to the worry first voiced by Britain's (future) prime minister, Arthur Balfour (1895), and recently echoed by Alvin Plantinga (2011), that Darwinism turned back on itself makes everything pragmatic and hence possibly totally mistaken. Within the Darwinian world, you can distinguish true from false. It is just that there is no absolute standard or guarantee of truth, like Plantinga's Calvinist God. Although some incautious Darwinians want to claim everything for their deity – Darwinism as religion in full-blown action – locating Darwinian epistemology in the past is precisely what a Darwinian epistemologist should do. If you complain that now I am making an analogical Darwinian epistemological argument as audacious or naïve as Kuhn, I never said that you shouldn't make such arguments. Just do them my way, not his!

I have long sneered at those like Wilson, who take a Spencerian view on Darwinian ethics. I may not have much love for G. E. Moore, given the deadening effect that his thinking had on twentieth-century, Anglophone philosophy. Yet – chiefly because (as noted in the earlier discussion of teleology) it is already in David Hume – I have always bought into his

[10] This whole business of cultural evolution has become somewhat of a cottage industry. I will simply give a friendly plug for a new, prize-winning article co-authored by Grant Ramsey, my co-editor of this *Elements* series (Ramsey and De Block 2017).

"naturalistic fallacy," embodying the belief that you cannot go from claims about matters of fact to claims about matters of morality. This warning is especially pertinent for evolutionary biology. Thomas Henry Huxley was quite clear about the way in which morality transcends the animal adaptations that helped us to arrive at our present evolutionary position. Yet, having now written a book on the Gaia hypothesis – the idea that the world is an organism – while I still do not buy into the full Spencerian vision, I am left with great admiration for those who take seriously the idea that our world is alive. Today's neo-pagans are a bit daft. A room full of stark-naked, earnest and rather humorless, moon worshippers, putting together a journal issue, is indeed a sight for sore eyes. Clad or unclad, they care deeply about the environment (Ruse 2013b). This reassessment was reinforced by a sabbatical in Stellenbosch, the wine-growing area of the Cape, in South Africa. It is the most beautiful place on earth. If a mining company proposed to lift the top off one of the mountains, for minerals, I would be the first to cry "rape." If that doesn't make me somewhat of a hypocrite, I don't know what does.

How do you take a more literal Darwinian approach? If Hume and Moore are right and you cannot justify moral claims by reference to physical things, including organisms, and if you don't like other options like God's will or Platonic nonnatural properties (Moore's choice), then perhaps the answer is that there is no justification! Moral claims are matters of sentiment, not reflections of objective reality. This doesn't mean that morality is nonexistent – rape really is wrong – but that it doesn't have any meaning outside human beings and their nature. If no one is around to hear them, there are no falling moral trees making noise in the wood. Rawls was right in appealing to Darwin to explain our moral nature – what is normally called "substantive ethics" – he was wrong in thinking that this is all to be said about justification – what (we have seen) is normally called "metaethics." Rawls eventually endorsed a Kantian position, where morality – the categorical imperative – is seen as the necessary condition for any kind of ongoing social interaction. Where he went wrong is not seeing that, in the world of evolution, the Darwinian adopts a neo-Kantian position, seeing morality as precisely the adaptation for social interaction. It is just that if we had evolved in a different way, we might think morally in different ways (Ruse 2012). Were we ant-like, come the fall, our highest moral directive would be to kick out of the hive all those useless brothers, who spent the summer doing analytic philosophy and ignoring Darwin.

Two final points and I will leave what is now called the evolutionary "debunking" argument about morality. First, at the substantive level, the Darwinian case has bite. People like the philosopher Peter Singer (1972) have

argued that morally we have equal obligations to all humans, known and unknown, friend or enemy, relative or not. The Darwinian thinks this lunacy and simply neither true nor really thought to be true. If anyone learned that I give all my money to the poor in Africa and my own children dress from Goodwill and eat at the Salvation Army soup kitchen, they would think me a moral monster. They would recall *Bleak House*, where Dickens is ferocious about Mrs. Jellyby, the philanthropist who spends all her time worrying about the welfare of an African tribe, to the entire neglect of her own family, let alone the poor in her own society, like Jo the crossing sweeper. Hume knew the score. "A man naturally loves his children better than his nephews, his nephews better than his cousins, his cousins better than strangers, where everything else is equal. Hence arise our common measures of duty, in preferring the one to the other. Our sense of duty always follows the common and natural course of our passions" (Hume 1739–1740, III, 2, i).

Parenthetically, a question that is properly of intense biological and philosophical interest is whether morality can be causally derived exclusively from an individual-selection perspective – selfish genes all the way – or whether one must allow group-selection mechanisms, where the good of the group must be the cause of change. I believe the former, and I now believe that Darwin thought this. It is not that we have no moral obligations to the starving in Africa, but that "charity begins at home." It is true that, in the *Descent,* Darwin talks of selection for the good of the tribe, but Darwin always thought of the tribe as a group of interrelated individuals, or who thought they were interrelated. In other words, although he did not have the sophistication of modern genetics, Darwin held a proto-form of what is now known as "kin selection" – benefit for the relative is benefit for the individual. I argue this in my contribution to *Debating Darwin* (Richards and Ruse 2017). In his contribution to this same volume, my dear, albeit-mistaken friend Robert J. Richards takes the contrary position. For modern support of the group-selection perspective by philosophers, see *Unto Others* (Sober and Wilson 1998) and, very controversially by biologists, an article in *Nature* on eusociality (Nowak, Tarnita, and Wilson 2010).

A second point. At the metaethical level, the Darwinian position is not all that unfamiliar. As it was for Darwin himself, it is a form of moral non-realism, often known as "ethical skepticism," meaning not skepticism at the substantive level, but at the level of justification. The "emotivists" in the twentieth century were prime examples. But there is and has to be more. I am sure I was not alone when, beginning the study of philosophy, I found emotivism deeply and offensively immoral. If I say, "rape is wrong," I mean rape truly is wrong. I don't mean – as the emotivists claim – that I don't much care for rape and now I am going to express my emotional dislike. Boo Hoo!

Or, in the more sophisticated prescriptivist version – "don't rape." The Darwinian ethicist recognizes that we have an evolved adaptation that makes us think that morality is objective, even though it isn't really (Mackie 1977). Morality is subjective, although – stress again – not rankly relative. It holds with humans as we have evolved, if not with ant-humans as we might have evolved. We have this adaptation because, if we didn't, we would start to cheat and morality would break down. So, we believe rape is truly, cross-my-heart-and-hope-to-die wrong. Our biology deceives us for our own good, and if you don't believe me, that's because it is doing a very good job on you.

Enough. The Darwinian Revolution was the most important intellectual and cultural event in Western society at least since the Reformation, if not of all time. It is not yet finished. I have barely sketched Darwinian epistemology and Darwinian ethics.[11] Thomas Nagel, as part of his rejection of Darwinism as science and hence the supposed reason for his rejection of the relevance of Darwinism for philosophy, whines that Darwinians have not yet demonstrated the processes behind the origin of life here on earth. I agree but I am relatively unworried (Ruse 2006). Although we do not yet have a solution, we have made huge progress on the problem – RNA worlds, deep sea vents as sources of energy, and so forth. I know in principle what a solution would look like. Nagel also moans that Darwin's theory cannot solve the body-mind problem. Again, I agree and I share with Nagel the belief that it is one of (if not the) most important of all unsolved problems (Ruse 2017b). It is so far beyond solution that I am not sure that even in principle it can be solved. I don't even know what a solution would look like.

Thomas Kuhn would say that this is precisely what we hear from people in a paradigm that is coming unstuck. Stay tuned, and all will be revealed! I am not quite that optimistic. Perhaps a new vision will come that, even if it does not solve the mind-body problem on our terms, does so on its terms. There are even now interesting teasers, like quantum entanglement that suggests that information can be transmitted instantaneously across the universe. I don't think this means that everything is conscious. Prince Charles is still mistaken when he goes to his greenhouse to talk to his plants. At least, I doubt they talk back, although does anyone talk back to a Prince of Wales? However, often-despised philosophies like panpsychism – philosophies that are monistic like that of

[11] In arguing for a Darwinized philosophy, am I not playing the same game as those whom I accuse of making Darwin's theory into a religion? I think not. For a start, I do not believe in biological progress in the sense of monad to man. I want a world view that does not have the faith commitments I see as common to both spiritual and secular religion. I am not offering an updated version of the Athanasian Creed.

Spinoza, seeing mind and body aspects of the same substance – could be due for a renaissance. In a Darwinian context, they will give us a new view on things. This was the position of the early Darwin supporter, the mathematician-philosopher William Kingdom Clifford:

> We cannot suppose that so enormous a jump from one creature to another should have occurred at any point in the process of evolution as the introduction of a fact entirely different and absolutely separate from the physical fact. It is impossible for anybody to point out the particular place in the line of descent where that event can be supposed to have taken place. The only thing that we can come to, if we accept the doctrine of evolution at all, is that even in the very lowest organism, even in the Amoeba which swims about in our own blood, there is something or other, inconceivably simple to us, which is of the same nature with our own consciousness, although not of the same complexity. (Clifford 1874, 2: 38–39)

I was mistaken originally about the relevance of Darwinism for any philosophical problems. Perhaps when it comes to the mind-body problem I continue to be mistaken or at least too timid.

After fifty years in the business, things are more exciting than they ever were. The Darwinian Revolution matters to philosophers. There is work to do. Let us stop talking and get to it. Better luck than I had with the posh journals!

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