The Darwinian Tension. Between Romanticism and Reductionism*

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1 Divisions

When talking about the relation between 18th century thought and the nature-culture problem in a society marked by the technological modification of nature in general, and of human nature in particular, there is something obvious, and there is something odd in referring to Charles Darwin and the doctrines of Darwinism. It is obvious that, in the past 145 years, interpretations of Darwinian evolutionary theory have played, and continue to play, a key role in conceiving of animate nature and its relation to human culture and society. The odd bit, of course, is that what I am talking about here and now, in 2004, dates back a mere 145 years, Darwin and his theory only coming to life in the 19th century. So where's "18th century thought" in this picture? I will argue that the epistemical sources of Darwin's theory are to be traced back to a division within (late) 18th century thought, namely that between enlightenment and romanticism, which in itself is well-known, but which remains little explored in its relation to the making of Darwinism, and to its further itinerary.

Darwinism quite frequently is taken to be the paradigm case of enlightenment style scientism, subjecting all phenomena in the animate world to the laws of variation, natural selection and adaptation—including the social behaviour of

*This work-in-progress paper is something like an embryonic version of a larger project I started at IAS-STS Graz—please think of "embryonic" in the epigenetical, not in the preformationist vein.

humans. Indeed, one of the standard topics in present day cultural criticism is that our self-perception as conscious actors is being re-cast into the forms of an evolutionary naturalism governed by the ideal of all-pervasive, purposeless, yet law-like mechanisms. The charge is that of reductionism, as the doctrine that all kinds of complex phenomena in all kinds of sciences, natural or social, may be explained by a limited set of natural laws which ultimately are, or may be derived from, the laws of physics. Suchlike reduction, it is feared, would eventually deny the humanities any privileged access to human affairs. For this suspicion, Darwinism often is rejected, being perceived as part of the problems inherent to the Western civilisation's traffic with nature.

However, that perception is at most half the truth (or, perhaps more accurately, a half-truth) about modern day Darwinism, and it is mostly untrue of the theory Darwin initially proposed. It is so in two respects: firstly, in its understanding of reductionism as it was part of Darwin's theory, and secondly in the exclusiveness with which it defines Darwinism as a reductionist theory—of whatever type.

Defining reduction: Accordingly, the first thing to do is to explicate the meaning of "reductionism". In the philosophy of science, reduction consists in the act of systematic translation of theoretical terms from one science into another. By doing so, one theory explains another theory, and, by implication, it also explains the latter's phenomena. It will now be fewer theories, and preferably simpler theories, catering for more phenomena. This is a principle in the economy of explanation. This economy of explanation however does not imply that—even if we accept a hierarchy of generality between sciences and their laws, with physics as the science of all matter on top—a special science like biology would be rendered obsolete by reduction to a more general science. On the contrary: If biology *could* be rendered in the terms of physics, one would have to show why it *should* be—for the sake of biology.[1]

It should be noted that reduction is concerned with theoretical statements, not with the properties of the substances under investigation. Yet reductionism, even within science, is frequently taken to be about "some immutable and ultimate structure of the universe."[2] What is at issue here is that the explanatory subordination of one science to another does not entail that the phenomena in question are in some way normatively subordinate and shall finally succumb to a physicalistic, mechanistic image of the world. What has to be paid attention to is to which kind of reductionism Darwinism subscribes.

Defining sources: The second preparatory task is to identify the two major epistemical and methodological sources Darwinian theory: Both enlightenment

[1] For this account of explanatory reduction, see (Nagel, 1961, ch. 11: "The Reduction of Theories")

[2] (Nagel, 1961, p. 363 f)

natural science and its apparent counterpart, romantic *Naturphilosophie*, arising in the late 18th century as competing interpretations of what science should be, were conjoined (interbred? hybridised?) in a unique way in Darwinian theory. Only enlightenment natural science subscribed to reductionism, and it did so only to the explanatory variety of that doctrine. Romanticism on the contrary denied the justification of *any* kind of reduction.

Instead of rushing to the premature conclusion that trying to be both a reductionist and a romanticist leads to self-contradiction, I believe that both traditions, in all their differences, were essential to the design of Darwinian evolutionary theory. They created a particular tension within that theory which opened up its characteristic field and mode of explanation in the first place. Taking for granted for the moment that there is such a thing like scientific progress, if we are looking for an example to show that such progress is not likely to live up to the rationalist's dream of an uninterrupted chain of valid inferences, then an analysis of this tension will help us to our paradigm.

2 What Matters to Science

What accounts for the predominant perception of Darwinism as being a reductionist science is that it introduced the ontological doctrine of materialism into biology. Indeed, reductionism about explanations presupposes that there are no ontological barriers between objects of explanation (e.g. mind vs. matter). Materialism, put very simply, maintains that the world is of one piece, which is, that there exist no entities and no causes in the universe that are not of physical nature. By implication, this means that the laws of physics apply to everything, anywhere, without exception. The doctrine of materialism however does not entail the necessity of applying the same mode of explanation to all kinds of phenomena in the physical universe (although it entails ultimate convergence of theories). Thus reductionism requires materialism, but materialism does not entail reductionism.

For biology, materialism implies that there is no metaphysical distinction whatsoever to be drawn between animate and inanimate nature—however different the modes of explanation for either realm may be. The presupposition of materialism is neither self-explanatory, nor has it been it taken for granted in most of modern biology. Until the advent of Darwinism, the sciences of life were marked off from the sciences of inanimate nature by a metaphysical, or at least by an explanatory, divide on whose former side vitalistic biology (or rather, the vitalistic biolog*ies* of all stripes) long prevailed—with an ancestry that can be traced back to Aristotle.[3]

[3] See especially his *On the Soul* and *Parts of Animals*. Even theories as heterogeneous as anti-evolutionist neoclassical biology (Cuvier, von Baer), the teleological evolutionism of the

2.1 The Living World

From antiquity onwards, biology had been interpreted as the teleological science *per se*, for being concerned with precisely those worldly phenomena which displayed a particular goal-directedness. Living beings, on this account, are goal-directed in three ways: Firstly, some organisms move around by themselves, towards and away from things and events in their surroundings, and all organisms are able to turn themselves towards certain states and events in the world (like water, light, or food). They do not do so in random fashion, nor is that behaviour externally caused. It rather seems to occur in pursuit of a purpose that is their own *natural purpose*—whether the organisms are conscious of it or not. Secondly, they are well-structured, integrated entities that *develop* their structure, without external guidance, out of more simple, or at least differently structured states. Thirdly, and most distinctively, they produce items developing a structure almost identical to their own, which happens in a fashion almost identical to their own way of coming about (like parent animals laying eggs that develop into organisms structurally homologous to their progenitors). By doing so, they form *lines of descent* to whose continuation the different traits of organisms contribute.

No direct observation is possible of what drives organisms; of what warrants for their integrity in the face of ever-changing arrangements of several, and themselves changeable, parts; and of what secures their structural homology over many generations. That organisms are best perceived as structurally integrated, which is, organised, self-propagating, and self-perpetuating entities is a conceptual decision on the background of the knowledge and the means of empirical investigation available. Those means, in ancient times, primarily consisted in the observation of organisms in their natural environments, identifying the structural and behavioural properties of organisms and their correlations with certain regular effects within themselves or within their environment. Since there were no means available of further analysis of those properties and correlations, the natural purposes and functions, that is, the final causes of organisms were the explanans, not the explanandum in classical biology.

The main tenet of classical Aristotelian biology and its descendants was that there are substantial properties to organisms that explain their structure and their behaviour—and their difference from inanimate objects. Their form (*eidos*), as their structuring principle, and their inner drive (their soul or *psyche*), are inherent to their matter. Accordingly, it is assumed that life can only come from other life, so that living beings must either have been around forever, or else must have entered the world by an act of divine creation. Either way the explanation of life could not be reduced to other, non-final causes. The self-developing,

Lamarckian / Geoffroyan sort, and the sometimes quasi-evolutionary romantic German *Naturphilosophie* (Schelling, Goethe) are all marked by the presupposition of vital forces of some kind. See (Nordenskjöld, 1926), (Lenoir, 1989), (Depew and Weber, 1995), (Richards, 2002).

self-propagating and self-perpetuating nature of living matter is given on a metaphysical level, inasmuch as it ranges over all living beings in general, and cannot be separated from them. At the same time it is not an abstract metaphysical principle governing individual lives (like a Platonic idea), inasmuch as the individual organisms themselves at the same instance *contain* and *physically realise* a form particular to them and their kin.

This form, or the species as such, is not defined by phenotypical similarity. Instead, species are defined by lines of descent, where form and soul are transmitted over generations. The specific forms the individual organisms embody in turn are defined by their natural purposes—that what the structure and behaviour that they inherited from their ancestors effects with regard to staying alive and reproducing. The natural purposes are different for every species, making for their *specific* properties. Although this might sound like modern adaptationism, there is a crucial difference:[4] In the order of nature, species are perceived as immutable, just *because* there is an integrated, complex order of nature, including mutual functional dependencies. The transmission of essential forms is what shall explain individual structures and behaviours, not the other way round. In this picture, any variation is degenerative deviation from the species-defining form.

In various (more or less faithful) incarnations the essentialist metaphysics developed by Aristotle informed not only biology, but also much of natural science up to modern times.[5] The observation that it seems outmoded and perhaps even unscientific from a contemporary perspective is not an objection against its longstanding cognitive achievements. It is the general mode of science that has been transformed in early modernity.

2.2 The Mechanical World

The transition from the Aristotelian tradition to modernity and, subsequently, enlightenment is generally linked with the emergence of Newtonian physics. However this transition did not occur at once. Being sciences of different domains, the new physics and neoclassical biology co-existed, however uncomfortably, for almost two centuries.

The methodological innovation effected by Newtonian science was that it tried to experimentally and mathematically isolate causes of events instead of moving from detailed and reliable descriptions of phenomena to metaphysical principles allegedly governing them. Carefully observing the orbits of planets, the acceleration of falling feathers and stones, and the trajectories of arrows and bullets

[4] For this observation, see (Depew and Weber, 1995, p. 40).

[5] See (von Wright, 1971, ch. 1: “Two Traditions”) for a lucid and concise comparison of the Aristotelian and the Newtonian approaches to science (only that von Wright selected Galileo instead of Newton as the figurehead of modern natural science).

will not yet give us the common laws of gravity by which all those things move. Simple, uniform and general laws can only be mathematically constructed from various instances of evidence across different sets of, perhaps seemingly unrelated, phenomena, carving out common patterns of causes and effects within them. Notably, such mathematical construction does not require the researcher to bring forward hypotheses as to what the force that is circumscribed by the law *really is*—it fully suffices to have the correct calculations and adequate experimental settings at hand to say *what kind of determinate effect there is* that can be ascribed to a force of that shape.

The novelty of this approach to *explanation* may be at least as important as the *ontology* on which Newtonianism was founded: that matter is inert, so that it is only moved by external forces; that all matter is made up of minute, simple particles; that causes and effects are determinate, so that they can be isolated in principle, and practically in experiment, allowing for deterministic predictions about future courses of events; and that, when the context of interfering causes is removed, the specific surrounding environment and the history of the entity in question—for they are the very interfering causes which are to be removed—do not matter with regard to the explanation of the phenomenon under investigation. This kind of individualistic ontology was a prerequisite of generalising over the causal patterns identified in physics towards incorporating the animate realm and beyond. However, it was not only Newtonian physics that ventured out to colonise the life-worlds of animals and humans. A romantic concept of science tried to counter the Newtonian conquest.

3 Contested Matter

The project of enlightenment may be equaled to the extension of the style of reasoning established in Newtonian physics, not only to animate nature, but to society as well. More precisely, enlightenment was the project of forming a distinctive set of general concepts and norms in pursuit of a epistemical and social order on the model of Newtonian scientific reasoning that were marked by individualism, rationalism and scientific formalism —although Newtonian science itself, emerging from a theistic, creationist framework of thought, had little ambitions in that direction.[6] Indeed, the mechanistic and causal image of the world that Newton's theory envisioned did not at all mean to remove purpose from that world, and to follow a secularised materialism. It is only that, where before purpose rested *within* matter, it now, as divine purpose, hovered *above* matter. After all, the crucial difference between an organism and a machine is that the fomer has its own purposes by nature, while the latter's purposes are endowed to it by its designer. Thus, part of the project of enlightenment was to remove

[6] This is what, for example, (Depew and Weber, 1995, p. 85 f) argue for.

divine purpose from the prevailing image of the world by way of ultimately turning the formal calculus and empirical methods of Newtonian physics against its metaphysics. God is a force that cannot be measured, and whose nature cannot be explicated.

What does this mean with regard to the extension of Newtonian physics to *biology*? Taking for granted that the laws of gravity and its allies could not directly explain the way organisms are structured and behave, there are three alternative ways to Newtonise biology—only the former two of which conform to the ideals of enlightenment:

(N 1) Special natural laws governing the animate realm could be derived from the more general laws of physics, therefore making biology reducible to physics. This endeavour became conceivable only on the advent of molecular genetics, the first science with a claim to reveal the biochemical patterns governing the processes of life (whatever may become of that promise).

(N 2) Physics could at least provide models for the explanation of organic processes, derived qua metaphor and analogical reasoning, but not seeking to make biology strictly reducible to physics. The proof of such model-building is the achievement of sustainable, testable hypotheses about organic processes. This is the route (or part of the route) Darwin was going to take.

(N 3) A structural homology obtains between the mechanism of inanimate nature and that of animate nature. While the former (the proverbial 'clockwork universe') could be explained on the model of human craftsmanship, the latter's complexity and functional diversification are beyond human grasp—and therefore have to be conceived of by a supreme being. This is the argument from design of Natural Theology, as brought forward by the Reverend William Paley.[7]

The ontological premiss shared by all extensions of Newtonian physics is that all matter is of the same, namely inert, simple, uniform kind, governed by the same natural laws—whether or not they were devised by god.

It was precisely this ontological presupposition that was challenged by the German romanticists, above all by Schelling and Goethe. Being descendants of Kantian idealism (although heretical ones), they did emerge from a intellectual tradition different from neoclassical Aristotelian biology of their own time, as it was

[7] Interestingly, Paley's doctrine exerted a strong influence on the young Darwin—and perhaps beyond. For this observation, see (Himmelfarb, 1959, p. 35 f), (Desmond and Moore, 1991, ch. 7: "Every Man for Himself"), (Richards, 2002, p. 541 f). For a discussion of Paley's worldview compared with Darwin's, see (Gould, 1990).

brought forward by Cuvier and von Baer. Nonetheless they shared the latter's vitalistic preconceptions, though extending them to all nature, animate and inanimate.[8] According to this kind of *Naturphilosophie*, nature in its entirety was to be perceived on the model of organisms, not of mechanisms, and it was to be epistemically grasped on the model of the mind.

Within the tradition of German idealism, there were alternative suggestions on how precisely to conceive of nature—the Kantian, enlightened, and the *naturphilosophical*, romantic:

(R 1) According to Kant, the primary faculty of the mind is reason—the categories and the order of inferences that could be identified a priori, abstracting from any empirical foundation.[9] The forms of reason that are to be found in logic and mathematics provided for all the necessary truths accessible to the human mind, thereby forming the conceptual bedrock for any empirical judgment. No determinative ontological judgment regarding whether nature ultimately *is* an integrated teleological structure or purely mechanistic is possible. However, Kant maintained, the natural laws of Newtonian physics, for being cast in the form of mathematics, provided for the safest possible transition from the analysis of reason to an empirical investigation of nature. The trouble for biology is that those laws could not account for the peculiar causal patterns of life: that living beings, for being functionally differentiated entities, for developing and reproducing, are causes and effects of themselves. The effect of a certain trait serves as the cause of its own continued existence as well as of the entire entity of which it is a part; in turn, the entire structure of which that trait is a part determines the latter's causal role in its perpetuation. Without perceiving organisms as purposefully structured, integrated wholes, those relations could not be identified. Since such purposes are not natural laws, biology had to choose a different route to knowledge, bypassing pure reason (and therefore pure science). That route is the ascription of purposeful design to animate nature, on the only subjectively given model of human purposes. Purposes in nature function as heuristic tools. Without them, we would not be able to understand the peculiar causality in question, but this manoeuvre will only tell us something about the conditions and limitations of human reasoning, not about some deep structure of nature.

[8] For an exposition of German romanticism from the perspective of the history and philosophy of science, see (Richards, 2002).

[9] For the following, see (Kant, 1790, Einleitung, pp. A xxiv–xxxvi, A xlvii–l; § 61, A 263–266; §§ 64–65, A 280–292; §§ 69–71, A 307–314; § 80, A 362–369).

(R 2) Starting from an initially similar set of idealistic premises, romantic *Naturphilosophie* moved towards opposite conclusions.[10] Idealism in general maintains that, since the mind is the only thing accessible to rational scrutiny by itself, it imposes order onto a world of phenomena which is not pre-ordered in a comprehensible way, so that the mind creates nature on the model of its own self-consciousness. In romantic *Naturphilosophie*, both the nature of that creative action and the nature of mind were interpreted in a much stronger sense than envisioned by Kant. Firstly, where the analysis of the forms of reasoning provided for the laws of nature in Kant, now the intuition, and also the senses and sentiments of the mind provided for a faculty which not only perceives and conceives of nature, but actively, dynamically, and compassionately forms it. Secondly, that "forming", although not to be taken in a literal material sense, amounted to *giving rise* to a world of natural phenomena as objects of the mind's experience. Accordingly, the apparent design to be found in nature is not a heuristic tool, but a feature of the mind reflected in all nature, animate and inanimate. Finally, the barrier between mind and nature imposed by idealism was torn down by way of introducing a dynamic, anti-Newtonian ontology, which postulated that mind and nature are two sides of one fundamental substance. In experiencing, and, by virtue of doing so, also constructing nature, the mind would encounter its *own* nature.

Taking this image of romanticism, it still would be misleading to force enlightenment and romanticism, and their relation to science, into a simple equation in which enlightenment would be on the side of pure science, while romanticism would be antiscientific, instead siding with the liberal arts. It was another kind of science that was envisioned in romanticism. That science echoed the natural history of ancient times.

If we engage in a natural history in the widest sense, which is, first and foremost, about accurately *describing* sets of phenomena, the practice of thorough observation, guided by reliable concepts to order it, indeed is the key to knowledge. While Kant would rely on the rational, logico-mathematical foundations of Newtonian science and only accept the introduction of subjective concepts as heuristic tools in a strictly circumscribed set of cases, for romantic science much depends on the quality, which is, the initial plausibility and the empirical sustainability of one's subjective intuitions. Since they are not only the starting point, but also the conceptual guide to investigation, it would be, first of all, most unnatural within this framework to abandon one's intuitions and scrutinise the object under investigation with explicit disregard to its phenomenal qualities. Although this does not mean rule out experimental approaches to one's object of

[10] Besides (Richards, 2002), (Heidelberger, 1998) was helpful for putting together this reconstruction of a position I am, I have to admit, still little acquainted with.

investigation, dissecting from it a vital force, a *Bildungstrieb* as the true cause of organic life in the same fashion as gravitational force can be determined to be at work in the movements of planets and bullets, was neither feasible, nor was it desired. Only immersion in and identification with nature would render a comprehensive image of it.

Accordingly, the real purpose of a scientific work is to evoke in the reader more than just a faint recollection of the perceptions and sentiments that the scientist, venturing out as a natural historian, had when he encountered nature. In this sense, good science has to share some of the qualities that characterise good poetry. It at least requires descriptive richness (instead of rigid formalism), but also an aesthetic sense for the intrinsic qualities of nature. Just to quote one programmatic sentence of Alexander von Humboldt, the leading romantic naturalist of the younger generation: "Ein Buch von der Natur muß den Eindruck wie die Natur selbst hervorbringen."[11] ("A book about nature must generate the same impression as nature itself." Just compare this to Galileo's famous dictum "The book of nature is written in the language of mathematics.") That paramount norm of romantic science was embodied impressively in von Humboldt's multi-volume *Relation historique du Voyage aux Régions équinoctiales du Nouveau Continent* and *Kosmos*, both based on his travels as a naturalist (among other things) to the Americas.[12]

4 The Two Souls of Darwinism

The motive of the traveling romantic naturalist is where, finally, Darwin enters the picture. It is well known that Darwin read von Humboldt's *Relation historique* when himself traveling to South America as a naturalist, and it is agreed that this book exerted a major influence on the young Darwin—even providing him with the motive for his *Beagle* voyage.[13] But does this mean that Darwin was a romanticist? Few would agree (above all, Robert J. Richards), while the vast majority of historians of Darwinism would not.[14] However I suspect that this is not the right question to ask—first of all because no statements of Darwin's could be cited giving an explicit, unequivocal answer to it, but only a variety of hints pointing into either direction. So was his soul then being torn between the realms of romanticism and the Newtonian tradition to which he was brought up to conform? This way of putting the question might not be quite to the point either,

[11](von Humboldt, 1825, p. 1571, afterword of the 1991 German edition, quoting a letter).

[12]See (von Humboldt, 1825) and (von Humboldt, 1845).

[13]This is what Darwin himself confesses in his *Autobiography*: (Darwin, 1905, Vol. I, p. 47). See also (Depew and Weber, 1995, p. 59), (Himmelfarb, 1959, pp. 46 f, 70), (Desmond and Moore, 1991, pp. 91,115 f, 119).

[14]For the controversy pro and contra Darwin the Romantic, see the last chapter of (Richards, 2002), vs. the review given to it by (Ruse, 2004).

at least if we are not talking on the level of biography and psychology, but of theory design, however informed it certainly is by the biography and psychology of the theorist. After all, it would be imaginable that Darwin at some time abandoned one framework (youthful romanticism) in favour of the other (grown-up science), so there might be only faint, if any, traces of the former to be found in his later scientific work. So let me suggest putting the question in the following way: Is there a systematic influence of both enlightenment natural science and romantic naturalism on Darwinian evolutionary theory, and if yes, in which ways does it occur?

Taking Darwin's enthusiasm for, and references to von Humboldt's work as the platform from which to set off for an answer, there is not only something remarkable in the fact that Darwin cheerfully related to that romantic naturalist with considerable enthusiasm, but also in the fashion in which he refers to his work. In Darwin's travel *Journal*, all scientific references to von Humboldt serve to elaborate on his own observations against the background of von Humboldt's descriptions of natural phenomena. This background encompassed both the concrete phenomena in question and their mode of description.[15] The mode of description that Darwin employed followed von Humboldt's ideal of romantic science, with all the shades of subjectivity, intuition and poetic sense.[16] On the other hand, von Humboldt was never cited in support of systematic theoretical investigations—mostly of course because Darwin did not really embark on such investigations in the *Journal*. When he moved to systematic theorising in his later works, scientists of another stripe than von Humboldt's would be Darwin guides.

If we can take von Humboldt as representative of the romantic tradition, and if the mainstay of that tradition's stance towards natural science may be circumscribed as a historical approach to natural phenomena, combined with a strong aesthetic apprehension of nature, emphasising the richness and the grandeur of

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[15] Von Humboldt's role as a guide to observation becomes explicit towards the end of Darwin's *Journal*: "As the force of impressions generally depends on preconceived ideas, I may add that mine were taken from the vivid descriptions in the Personal Narrative of Humboldt, which far exceed in merit anything else which I have read." (Darwin, 1913, p. 534)

[16] Perhaps the most beautiful and instructive passage in Darwin's *Journal* is the following: "During this day I was particularly struck with a remark of Humboldt's, who often alludes to 'the thin vapour which, without changing the transparency of the air, renders its tints more harmonious, and softens its effects.' This is an appearance which I have never observed in the temperate zones. The atmosphere, seen through a short space of half or three-quarters of a mile, was perfectly lucid, but at a greater distance all colours were blended into a most beautiful haze, of a pale French grey, mingled with a little blue. The condition of the atmosphere between the morning and about noon, when the effect was most evident, had undergone little change, excepting in its dryness. In the interval, the difference between the dew point and temperature had increased from 7.5° to 17°." (Darwin, 1913, p. 33).
The other references to Humboldt in this work include ibid., pp. 12, 17n1, 22, 29 f, 93n1, 97n1, 102, 138n2, 259, 263n3, 304n1, 317, 375 f, 390, 392, 415, 463n1, 464n1, 531.

phenomena, then what Darwin inherited from von Humboldt was indeed this: his particular apprehension of natural phenomena. What Darwin did not inherit was the theoretical approach of vitalism and its underpinnings in metaphysical speculations about the unity of mind and nature as a creative force that, even willfully, neglected the norms of scientific explanation established in Newtonian physics. On this side, he followed the latter paradigm in its enlightened variety. Putting this observation in the vocabulary of the philosophy of science: Romanticism provided Darwin with a particular *observation language*, while Newtonian natural science delivered to him the *theoretical models* on which to base his *explanation*.

It might be objected that the distinction between the levels of description and explanation which I am drawing here is somewhat uneasy, since the way phenomena appear within a science interacts with explanations and background assumptions already at hand, and vice versa. This is true, but this very interaction, I believe, is what created the productive tension within Darwinism I alluded to above (sec. 1, p. 3).

One could look for causes within the social and scientific context in which Darwin worked that could explain why he adopted a strictly materialist, causal, mechanistic and individualistic mode of explanation. Indeed, in contrast to *Naturphilosophie*'s prevalence in Germany, Newtonian science (to a significant extent still in the orthodox, pre-enlightened interpretation) was so dominant in late 18th and early 19th century British science that, if one wanted to be taken seriously within that scientific community, one would be in trouble if not subscribing (or at least paying lip service) to the Newtonian canon in some way or another—even more so if one wanted to bring forward a theory that ventured out into new fields.[17] Methodological conservatism apparently would be a good *strategic* advice under those conditions. If we additionally take into account that Darwin himself, for scientific or for personal reasons, fell out of step with Christian faith, the de-theologised materialism as whose figurehead Darwin serves until today seems to be the natural consequence. However, although these are selectively relevant conditions for Darwin's explanatory framework, the picture would be incomplete without identifying more compel ling *methodological* reasons for taking this route.

When Darwin embarked on a theory of species transmutation, he had to face a methodological problem: Being a empirical sciences, biology is obliged to concern itself with matters open to observation and / or experimentation. Yet there were several obstacles to such investigation into natural history that arose in Darwin's time, all of which were connected to the fact that recent geological findings on the age and the transformations of the earth, and the new light they shed on the fossil record, called the fixity of species into question:

[17] See (Depew and Weber, 1995, pp. 70–72)

(E 1) Both the complexity of the phenomena within the history of nature and the geological time-scale on which that history unfolds are beyond the cognitive grasp of humans, simply because they evade direct and reliably comprehensive perception, and because they are foreclosed to experimentation, for not possibly being subjected to the controlled and reproducible conditions essential for the experimental sciences.[18] If natural history relies on the observation of natural beings in their natural environment, the prospect that life-forms and their mutual relations indefinitely change, and that they do so over millions of years, expands natural history's subject area beyond any reasonable limit.

(E 2) On the geological finding that natural history operates on a timescale much larger than assumed by orthodox creationists, historical evidence about the history of life became ever more important, while at the same time what Darwin called "the imperfection of the geological record"[19]—being entailed by those findings—rendered that historical evidence scattered. Accordingly, recounting the history of life detail by detail now seemed virtually impossible.

(E 3) Natural history as such in the first place concerns itself with empirical regularities whose discrimination is observer-dependent. Darwin took pains to demonstrate, on his observations about the fertility of crossbreeds, that there is no essentialist, a priori definition possible of what marks off species from mere varieties of organisms. Species can only be defined heuristically, by relating community of descent within populations to structural affinities between the individuals. Any grounding of the species / varieties distinction beyond that was now lost.[20]

In the face of these difficulties, the theories in natural history available resorted, more than ever, to the notion of design—of whatever kind: the divine creation of Newton and Paley (mirrored in the hypothesis of special creation) the naturally inherent teleology of Aristotle and the vitalists (echoed in Lamarck's dynamical evolutionism), or Kant's scepticism about the possibility of a Newton of a blade of grass ever to arise, so that we cannot move beyond the notion of design, even if we should.[21] However all of these attempts at attaching purpose to nature posed an epistemical problem that Darwin captured in the following way:

[18] For the cognitive problem of grasping the geological timescale, see (Darwin, 1859, p. 481), for the complexity of interrelations, and our ignorance thereof, see ibid., p. 71, 73, 77.

[19] See (Darwin, 1859, ch. 9, esp. p. 288, 292, 295).

[20] For Darwin on the problems of defining species, see (Darwin, 1859, pp. 51, 138, 177, 267 f, 411, 420, 485).

[21] See (Kant, 1790, p. A 334).

> "It is so easy to hide our ignorance under such expressions as the 'plan of creation', 'unity of design,' &c., and to think that we gave an explanation when we only restate a fact."[22]

The main problem to the explanations of nature as purposeful was that the notions of purpose they employed were not open to further analysis. Instead of such analysis those explanations postulated unobservable forces (or, for Kant's sake, the principled unobservability of forces) that were justified on a level above and beyond empirical science itself: divine revelation, the metaphysics of life, or the nature of mind. The materialist premises from which Darwin started—and which, together with modern physics, took part in setting the standards for all natural science to come—thus had a systematic rooting rather than simply an ideological one: What can neither be proved in existence nor be analysed into causes and effects is a poor guide to explanation. This insight gave rise to a research programme aiming at an explanation of natural purposes and design in terms of causes and effects. Its logic may be reconstructed like this:

(P 1) If explanation in natural science is defined as identifying the causes of events, subsuming them under natural laws and evidencing them empirically (instead of postulating forces as causes that evade such scrutiny),

(P 2) if the assumptions within former theories in natural history that species are fixed, and that the development of organisms follows teleological principles inherent to them fall short on requirement (P 1),

(P 3) if the apparent design in animate nature thus has become a problematical fact, therefore becoming the explanandum (instead of the explanans) of natural history,

(P 4) if the true causes (the *verae causae* Darwin was looking for)[23] of those apparently purposeful phenomena shall be identified in an explanation on the best empirical evidence and the best theory available,

(P 5) but if the best evidence available in natural history is insufficient to reveal the causal structure of the phenomena in question (for the complexity of interrelations in nature, the imperfection of the geological record, the lack of experimental access to the natural modification of species, see D 1–3),

(P 6) if then, Newtonian physics is the paradigm of causal explanation in the natural sciences, adhering to requirement (P 1), and

[22] (Darwin, 1859, p. 482)

[23] For Darwin's invocation of *verae causae*, see (Darwin, 1859, p. 167, 352) See also (Depew and Weber, 1995, p. 66).

(P 7) if the scattered evidence at hand in natural history does not *require* the scientist to presuppose that animate and inanimate nature belong to different ontological realms, governed by different natural laws,

($\Rightarrow$ C) then using models derived from a Newtonian theory and transferred to the sciences of life would be the most promising candidates for generating a causal explanation with a promise of (ultimately) meeting the above requirements (P 1 and 4).

The main problem for a theory designed on these premises is that it may not start from seemingly natural intuitions. Of whatever shape such intuitions had been up to Darwin's day, they showed unsatisfactory results when being cited as explanantia. Instead, Darwin encourages that the naturalist's "reason ought to conquer his imagination" and suggests to start from assumptions that actually *counter* natural intuitions about design in nature, in granting that purposeful structures may arise in nature without the guidance of intentional design, but by natural laws alone, without resorting to a divine legislation modeled on human purposes.[24] On the other hand, Darwin and his contemporary science could not give the detail of physical causes operating in evolution, thus *in practice* not allowing for a proper explanatory reduction of that process to a physicalistic explanation. This is why Darwin's theory proceeded by analogy and scientific metaphor—which is the complement to explanatory reduction: using a concept taken from an established field of knowledge to re-describe another field, so that new hypotheses about the latter's subject matter can be generated and tested.[25] This, in turn, is why Darwin's theory retained the heuristics of purposes that Kant thought to be irreducible *in principle*.

Darwin introduces the laws of natural selection in several steps, proposing a series of analogies and metaphors, and linking them to the scattered evidence available: Firstly, he gives an account of the capacities the art of breeding has regarding the modification of organisms over generations by intentionally selecting varieties, on the observation that variations occur naturally and are inheritable (while acquired characteristics are not). So there are varieties of organisms that could be shaped and altered by an agent. He then calls into question the distinction between such varieties and proper species, arguing, on evidence of experiments testing the fertility of crossbreeds (infertility so far having been esteemed as the mark of distinct species being crossed), that the distinction is gradual. The first two steps lead him to the conclusion that species may be altered by some cause if that cause exerts a pressure analogous to the breeder's selection. Species alteration could now be conceptually grasped on the human timescale.

Having established this, in order to identify the cause of such alteration in nature, the theory in a third step draws on two extensions-by-analogy of Newtonianism

[24] (Darwin, 1859, p. 188)

[25] For this account of the role of analogy and metaphor in science, see (Hesse, 1966).

that were actually first applied to *society*: the doctrines of Robert Malthus and Adam Smith.[26] From Malthus Darwin derived the principles of population development. Under unchecked conditions, any population would increase faster than food supply, so that a struggle of existence between individuals obtains. This struggle in turn provides for the checks, by destruction and non-procreation of those individuals who do not match the conditions imposed upon them by their environment. The principle of population, for (if true) indiscriminately applying to all populations, human or other, was perceived as a general law of nature (although it pretty obviously was an ideological notion, too), coming as close as possible to the real causes Darwin's theory was striving for. This law (or quasi-law) was matched onto the observation that variant life-forms relate to their physical environment and to one another in different, and complementary, ways, thus diversifying and ultimately developing the complexity of interrelations to be found in nature. This idea of the divergence of character was lifted from Adam Smith who contended that labour and social organisation become more efficient if diversified. So if there is inheritable variation, and if there is some selective pressure on organisms exerted by their environment, and if there are different ways of matching environmental conditions and if to the environmental conditions, then a diversity of species shaped by the conditions of adaptation by natural selection will be the result.

Exactly this is where Darwin's romantic observation language complements his quest for strict natural laws. If animate nature had been perceived in the fashion of a mechanism, and then explained as such a mechanism, either the complexity of interrelations and the richness of natural varieties would have been lost in a simplification that moved beyond *explanatory* reduction, or the mechanism of explanation would have been rather powerless with regard to accounting for that richness. The initially counterintuitive point of Darwin's doctrine is that the struggle for existence, resulting in natural selection, in its very simplicity and harshness, explains the beauty and complexity of natural adaptations whose grandeur exceeds anything human craftsmanship could achieve.[27]

Just as Darwin's reductive style of explanation countered the romantic ignorance of the true causes of evolution, his romantic perception of nature prevented him from oversimplification—and from a misperception many of the critics of Darwinism frequently alleged to that theory: that, by introducing the laws of variation

[26] See (Darwin, 1859, pp. 5, 67), (Darwin, 1905, p. 68), (Darwin, 1909, pp. 7 f, 88 ff) for Darwin's references to Malthus. The Smithean sources are implicit, and therefore harder to trace. The link between divergence of character and the concept of division of labour is made in (Darwin, 1859, p. 93, 112 f). See (Depew and Weber, 1995, p. 81 f) and (Gould, 1990, p. 148 ff) for arguments in favour of an interaction of Malthusian and Smithean insights in Darwin's conception of natural selection.

[27] See (Darwin, 1859, p. 60 f). But, of course, see especially the oft-quoted concluding paragraph of the *Origin*, ibid, p. 489 f, including the "entangled bank" metaphor—which I need not quote here once again.

and natural selection, the necessary *and* the sufficient conditions, and thus a comprehensive causal account of evolution, allowing for determinative predictions, are given. Evolution is, above all, a historical phenomenon, not something that could be isolated and reproduced in a laboratory.[28] The peculiarity of historical phenomena is that, if one wanted to give a full account of them in terms of an explanation by natural laws, the more accurate that account became, the less explanatory it would be. For all the irremovable modifying conditions, imposed on the course of events in manifold ways that ask for explanations in their own right, one would end up with the description of a single case.[29] The law of natural selection is introduced at the most general level. If properly defined and defended, it is to be accepted as a, and most likely the salient, but still only a necessary cause of evolution. It explains how it could have happened that we face a bewilderingly complex animate nature, but it could not determine the growth of every branch and twig of the tree of life.

5 Conclusion

I have argued that Darwinian evolutionary theory arose from the tension between the acknowledgement of the bewildering complexity of the animate world and the systematic necessity of explaining it in the terms of universal natural laws. If this is true, then both sources of Darwinian theory should be acknowledged as systematically important rather than just as influences and inspirations: If one did not embark on a quest for some kind of natural law acting in animate nature, evolution would either have continued to be ignored altogether, or it would have continued to be explained by some argument from design, instead of its basic patterns of design being thoroughly explained. If, on the other hand, one believed that identifying some natural law by way of hypothesising, model-building and empirical testing, achieves an overarching, reductive explanation of the whole complex phenomenon of evolution one would miss the very quality of the phenomenon which gave rise to the inquiry into the laws that may govern it. In this sense remembering the Darwinian tension may help to resolve the ideological and scientific controversies about what is the one and only true source of Darwinism, and to restore the full picture of that theory.

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[28]The essentially historical character, and that is, the irreversibility, of evolution is acknowledged in (Darwin, 1859, p. 313 ff).

[29]This argument, originally brought forward by William Dray, has been vindicated in (von Wright, 1971, p. 24 f). See also (Rosenberg, 2001).

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