The Economy of Nature in Classical Natural History

Staffan Müller-Wille

University of Exeter, Exeter, Great Britain; S.E.W.Mueller-Wille@exeter.ac.uk

One of the most fundamental conceptual changes in the history of the life sciences, though a largely unnoticed one, occurred with regard to the notion of the economy of nature. In its most developed versions in the eighteenth century, the economy of nature was seen as governed by eternal laws that guarantee a stable equilibrium: destruction and generation of individual beings held such proportions, that the place of each extinct individual would be taken in by another individual that was identical in nature. In a whole series of developments, highlighted by François Jacob in his *Logique du vivant* (1970), this stable relation of forms and places of life was shattered around 1800: taxonomy, biogeography, and stratigraphy interlocked to uncover the contingent relationship between organization and environment and to disintegrate the ties between the history of life and the history of the earth. In Darwinism, finally, the economy of nature was one, in which life forms occupied places that had previously been inhabited by different forms, the former thus displacing the latter. Balance in nature was now fundamentally instable, and the relations between beings fundamentally unproportional. In my paper I will try to follow this shift from Carl Linnaeus's *Oeconomia naturae* (1749) over Lyell's *Principles of Geology* (1730–1733) to Charles Darwin's essay on *The Structure and Distribution of Coral Reefs* (1842).

***Keywords*:** Regulation, History of Ecology, Carl Linnaeus, Charles Lyell, Charles Darwin.

Metaphors between economy and nature have received much less attention by historians of biology, although they are both logically and historically prior to the machine-organism analogy.[1] These metaphors have indeed a very long history: Concepts like debt and compensation, balance, checks and counterchecks, competition, division of labor have informed the philosophy of nature since antiquity when it came to the description of interactions among plants, animals, and inanimate nature. A reason for the neglect of these metaphors may be that it was only a rather short period in which an explicit discourse organized around 'the' economy of nature existed. This period coincides with the heydays of natural history and can thus be roughly demarcated by Carl Linnaeus's *Systema naturae* (1735), the Swedish naturalist's famous work in which he introduced binomial nomenclature, and Charles Darwin's *Origin of Species* (1859). Before this period, balance arguments appear every now and then, but do not form an organized theoretical framework as a guide to systematic research. After Darwin, the economy of nature gave way to various theories of organic evolution and persisted in the biological sub-discipline of ecology only.

In this paper I would like to substantiate two claims with regard to this rather short lived explicit discourse of an economy of nature. First, that the advent of this discourse in the mid eighteenth century signals a fundamental change in the history of the life sciences. It was only then, in the work of Linnaeus, that the "economy of nature" became articulated in what might be called the first general and, above all, autonomous theoretical framework for the life sciences. This articulation turned around a fundamental distinction between organic reproduction and the environment of organisms. Reproduction and environment were thus conceived as independent spheres, each of them subject to its own laws respectively and each of them contingent with respect to the other. As a consequence, regulation became a matter of explicit conceptualization for naturalists.

[1] Thus Canguilhem (1988) spends only two paragraphs on discussing this aspect.

It is an irony, however, and this will be my second claim, that it was exactly the distinction of organic reproduction and environment, which ultimately led nineteenth-century naturalists, particularly Charles Lyell in his *Principles of Geology* (1830—1833), to doubt the idea of a balance of nature in the sense of perfect adaptation and stability in the living world. Regulation thus became transformed from an inherent, cosmological principle that was the source for eternal stability and order, to an explicit concept by which an occasional "triumph over instability" only, an occasional "recovery from degradation," as Georges Canguilhem once put it, was explained (Canguilhem, 1988, p. 86). The economy of nature, and the regulatory mechanisms it incorporated in the nineteenth century, guaranteed survival of some only, not life as such, and it did so at the expense of other living beings, on the condition of a massive, quasi-geological volume of displaced and outcompeted bodies — not a tree of life, not even a coral of life, but a coral reef of life, covered by a thin layer of living matter, yet, in its core, very, very dead throughout.[2]

Pre-Modern Conceptions of the Balance of Nature

To assess the achievements of Linnaeus more precisely, I would first like to paint a small panorama of the long, pre-modern history of economic metaphors in natural history and natural philosophy.[3] The problem that gave rise to these metaphors can be put in a simple question: How is it that the number of individuals comprised by each kind of living being remains stable? How is it, to use an example put forward and indeed actively researched by Herodot, that the birds, beasts, and men do not eat all the rabbits? Herodot's answer was:

> "Divine Providence does appear to be, as indeed one might expect beforehand, a wise contriver. For timid animals which are the prey to others are all made to produce young abundantly, so that the species may not be entirely eaten up and lost; while savage and noxious creatures are made very unfruitful."[4]

Herodot's argument here is one of compensation: the losses some animals accrue due to their timidity are compensated for by the gift of fertility, while the losses that "savage and noxious" animals inflict on others by consuming them are compensated for by barrenness. The balance of nature is primarily a moral balance, a balance of punishments and retributions. Although such arguments seem straight-forward, even simple-minded, ancient philosophy knew of a rich variety of complex rationalizations for the balance of nature. Thus Anaximander, one of the earliest pre-socratic natural philosophers, believed, that "the source of coming-to-be for existing things is that into which destruction, too, happens according to necessity; for they pay penalty and retribution to each other for their injustice according to the assessment of time".[5] Aristotle on the other hand, as always focused on the teleology of the individual organism, explained the balance of nature as a balance between consumption of nutriment and secretion of residual matter in generation.[6] Cicero, finally, in *On the nature of Gods*,

[2] Horst Bredekamp argues that Darwin's model for the "tree of life" was not a tree, but a coral; see Bredekamp, 2005.

[3] I base my account on a series of articles written by Frank Egerton in the late sixties and early seventies; for a summary see: Egerton, 1973.

[4] Quoted according to Egerton, 1973, p. 326.

[5] Quoted according to Egerton, 1973, p. 325.

[6] Quoted according to Egerton, 1973, p. 328.

invoked the prolific omnipresence of seed, "enclosed in the innermost part of the fruits that grow from each plant", and both providing mankind "with an abundance of food" as well as "replenishing the earth with a fresh stock of plants of the same kind".[7]

Despite the variety of notions that entered into the rationalizations of the balance of nature in antiquity, and which should govern natural philosophy till the seventeenth century, it is possible to make three general remarks about them. I want to borrow the first from Canguilhem, who in discussing Leibniz's theodicy made the following comment that in my view holds for the balance conceptions of Anaximander, Aristotle, and Cicero as well:

> "There is no disparity between rule and regularity [in these conceptions]. Regularity is not obtained as an effect of regularization, it is not a triumph over instability or a recovery after degradation. Rather, it is an inherent property. A rule is a rule, and always remains so; its regulatory function, never actually invoked, remains latent" (Canguilhem, 1988, p. 86).

The second remark pertains to the nature of the balance: In all three conceptions quoted, it is a balance of two counteracting forces: debt and compensation in Anaximander; consumption and production ("excretion") in Aristotle; provision of food for others and multiplication of ones own kind in Cicero. The third remark, finally, is a corollary of the second: the relations established between organisms through the balance of nature are asymmetrical throughout, relations of provision, obligation, tribute, and retaliation. This is why Anaximander makes a reference to the "assessment of time": give and take, consumption and production, coming-to-be and passing-away, are not just simultaneous aspects of one and the same transaction, they follow upon each other in time. This came to the fore specifically in the elaborate cosmological theory of Aristotle, which accounted for the perpetuation of mortal beings through the annual cycle. No one less than William Harvey, the discoverer of the circulation of blood, rephrased it in the seventeenth century, and it was still upheld in the nineteenth century by no less a figure than Auguste Comte.[8] Harvey's version of the theory was particularly concise:

> "The male and female, therefore, will come to be regarded as merely the efficient instruments [of generation], subservient in all respects to the Supreme Creator, or father of all things. In this sense, consequently, it is well said that the sun and moon engender man; because, with the advent and secession of the sun, come spring and autumn, seasons which mostly correspond with the degeneration and decay of animated beings. So that the great leader in philosophy [i.e. Aristotle] says: 'The <…> motion <…> of the ecliptic is [the cause of generation and corruption], this being both continuous and having two movements; for, if future generation and corruption are to be eternal, it is necessary that something likewise move eternally, that interchanges do not fail, that of the two actions one only do not occur'"[9]

The production of living beings is here conceptualized as the result of a series of causes, which reaches from the stars above down to individual parents. A state of nature that is prolific must therefore be succeeded by a state of nature that is barren. Clearly, a statistical picture, in which large numbers of simultaneous destructive and productive events cancel out each other, thus maintaining a balance on the whole, lies beyond the horizon of this world-view.

---

[7] Quoted according to Egerton, 1973, p. 330.

[8] See Canguilhem, 1988, p. 94–96, on Comte's version.

[9] Harvey, 1847, p. 363. The passage quoted from Aristotle is De gen. et corr. 336a32-b2; on this aspect of Harvey's Aristotelianism see Gregory, 2001.

Linnaeus on the Economy of Nature

Frank Egerton has diagnosed a fundamental change occurring in the eighteenth century with respect to conceptions of a balance of nature. According to him, it was Linnaeus who, first of all, coined the expression "economy of nature" for the balance of nature, and who, secondly, used this concept as an organizing principle to unify a "previously amorphous" part of natural history, thus transforming "an important background concept into a central theory of a new science" (Egerton, 1973, p. 335). With respect to the content of that concept, Egerton relied on the work of the French historian of science Camille Limoges, who had analyzed Linnaeus's concept of an economy nature in the following way:

> "One can represent [Linnaeus's] theory by imagining a pyramid in which the geographical distribution of the species represents the base, with the phenomena of propagation, preservation, and reproduction representing the other three sides. The apex by which the surfaces are held together is the idea of proportion" (Limoges, 1972, p. 10, n. 10; Engl. translation according to Egerton, 1973, p. 336).

This is indeed a good illustration of Linnaeus's theory (see fig. 1): As is well known, Linnaeus believed that, at the beginning of times, each species of organisms was represented by a single pair of individuals, or, in the case of hermaphroditic organisms, one single individual, each of these individuals directly created by God. All of these divine creations, moreover, were placed on an island, the original Garden of Eden, located at the equator and equipped with a high mountain. The island thus provided niches — "stations" as Linnaeus called them — serving the needs of every single species. Earth history then occurred as a mere history of expansion, both by the multiplication of individuals within each species, and by the extension of the earth's surface through geological processes of accretion and sedimentation taking place at the shores of the landmasses. The end product of this expansive movement is the present day geographical distribution — or what Linnaeus called the "habitat" — of species. The stability of this process was guaranteed, according to Linnaeus, through the exact proportion between three forces forming the edges of Limoges' pyramid: propagation, preservation and destruction. And this

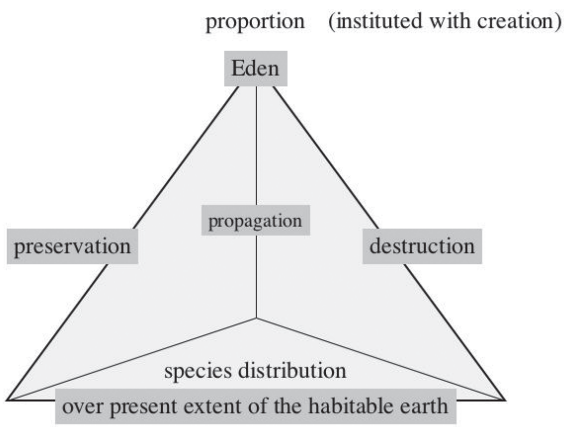

Fig. 1: Schematic representation of Linnaeus's economy of nature based on the discussion in Camille Limoges, "Introduction", in Charles Linné. L'équilibre de la nature. Paris: Vrin, 1972. P. 7–24.

proportion, again, had once and for all been instituted in creation through laws laid down by the Creator. This is how Linnaeus once put this:

> "Nature is God's law, laid into things, according to which they are multiplied, preserved, and destroyed by necessity. [This law] was laid down by the omnipotent Ruler, who has no need to revoke or change it" (Linné, 1757/1788, p. 113).

Despite its clarity, Limoges's presentation of Linnaeus's theory of an economy of nature as a "pyramid" of proportioned processes leaves open some important questions. First of all, why is it, that proportion emerges as an additional, explicit principle or "law", a feature that Limoges recognized as peculiar for Linnaeus's theory with respect to what went before? (Limoges, 1972, p. 10). Secondly, why does Linnaeus speak of laws "laid into things" rather than imposed upon them from outside? And thirdly, why does Linnaeus's theory form a pyramid and not simply a flat triangle? The propagation of the species and the preservation of individuals, two distinct sides of Limoge's pyramid, appear, after all, to be just two aspects of one of the same process: reproduction achieved through "destruction", i. e. consumption of nutriment.

To answer these questions it is useful to take a closer look at the central passage in Linnaeus's essay *Oeconomia naturae*, in which he tried to define the economy of nature:

> "Whoever directs his attention to the things, which occupy our terraqueous globe, will finally admit, that it is necessary, that all and each are arranged in such a series (*serie*) and in such mutual connection (*nexu inter se*), that it aims at the same end. <…>. So that natural things may last in a continued series (*continuata serie*), the wisdom of the highest Being has ordained, that all living beings perpetually work for the production of new individuals, and that all natural bodies reach out a helping hand at their neighbor for the conservation of each species, so that what serves the ruin and destruction of one of them, serves the other's restitution" (Linné, 1749/1787, p. 2—3).

From this passage it becomes clear, that Linnaeus was actually not distinguishing three concurrent processes, namely propagation, preservation, and destruction, but on a more fundamental level two dimensions along which these processes were distributed unequally (fig. 2): a synchronic, mutual connection in space (*nexus inter se*), and a diachronic series (*series*) in time. If we imagine these two dimensions as the axes of a coordinate system, the processes of destruction and preservation/restitution of individual beings are aligned with the horizontal axis, the *nexus*, while the production of new individuals, or propagation, is aligned with the vertical axis, the *series*.

The term *nexus* used for the first dimension witnesses remnants of a pre-modern conception of economy — according to Marcel Mauss *nexus* had the legal and religious connotation of a personal obligation implied by the transfer of goods (Mauss, 1997, p. 229—232). It is obvious, however, that Linnaeus tries to characterize the relation as a symmetric one, as a relation of "neighbors reaching out a helping hand to each other". And indeed, one of the main points Linnaeus tried to make in his *Politia naturae*, published some ten years after the *Oeconomia naturae*, was that predators actually "serve" their prey by cutting down their number, so that the latter would not destroy themselves by destroying their means of subsistence through overpopulation (Limoges, 1972, p. 14).

Now, as already mentioned, it is possible to see the *series* as a mere extension of the processes forming the *nexus* between organisms, by treating it as a mere special case, as e. g. Aristotle did, of the consumptive production of offspring. Why, then, would Linnaeus set it off terminologically as a dimension in its own right? The answer lies in the species definition of Linnaeus: Linnaeus believed that the reproduction of living beings followed "inherent laws of

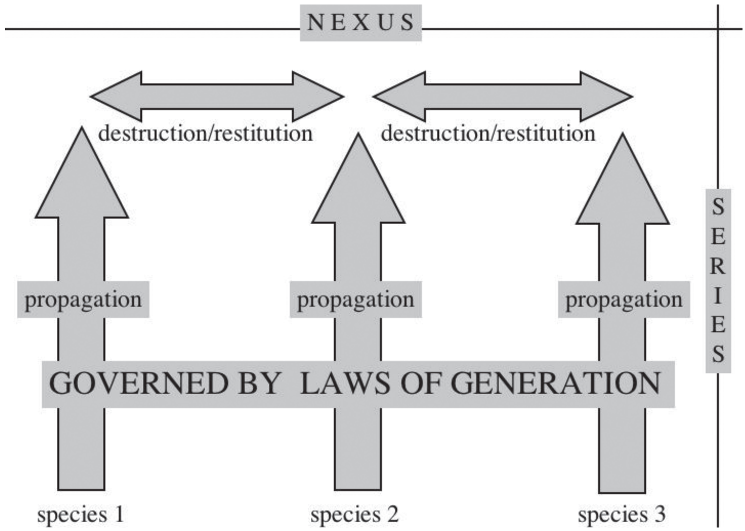

Fig. 2: The dimensions of *series* and *nexus* in Linnaeus's economy of nature.

generation", according to which individuals belonging to one and the same species "produce more, but always similar" individuals, doing this independently of "place or accident".[10]

If such "laws" indeed exist, the economy of nature is clearly not exhausted by local relationships of domination and servitude, of destruction and restitution. Each individual would enter these relations as part of the "continued series (*continuata series*)" of its particular species. It would thus be determined as a member of that particular species by the laws of generation already and independently of the particular environment it happens to find itself in.[11] And since, according to the laws of generation not only similar, but also "more" individuals are produced with each generation, Linnaeus's economy of nature includes a portrayal of nature as a system of autonomously reproducing beings spreading over localities, where they relate to each other as independent transactors of goods and services in the form of their own, prolific bodies.

This became much more explicit, when Linnaeus took up the theme again in 1760, in the already mentioned essay *Politia naturae*. This essay, which is otherwise known mainly for its comparisons of "ecological" relations with relations of political dominance (Spary, 1996, p. 178–181), opens with a metaphor pointing surprisingly far beyond these similes: At first sight nature just seems to be a war of all against all, where one sees "one animal tear to pieces the other in astonishing tyranny". After closer observation one has to admit, however, that:

> "<…> it is difficult, if not impossible, to discern beginning and end in divine works. In a circle, namely, runs everything. No less so than on weekly markets (*in nundinis*). At first one only sees, how a great mass of people spreads out in this or that direction, while nevertheless each of them has his home (*domicilium*), from where he approached and to where he will proceed" (Linné, 1760/1764, p. 18).

[10] On Linnaeus species concept see: Müller-Wille, 2001.

[11] This notion of species as a "series" of reproductive events was shared by Linnaeus' great opponent George Louis Leclerc Comte de Buffon; see: Rheinberger, 1990.

We can see now, why Linnaeus's economy of nature constituted a "pyramid" rather than a triangle: it is actually the rate at which individuals merely multiply within a species, each respectively governed by its own "laws of generation", which regulates the balance of destruction and restitution according to his theory — with destruction and restitution becoming, in a quite literal sense, two sides of one and the same coin. Moreover, we see, why proportion emerges as a principle in its own right, a "*principe regulateur*" as Limoges has called it (Limoges, 1972, p. 10). In the end, it is the proportion between the severally determined but mutually independent multiplication rates of different species that upholds the balance of nature, and this proportion alone. Lions would indeed eat all the rabbits, as they multiplied according to their own laws of generation — if it were not for the exact proportion that reigned between the multiplication of lions and the multiplication of rabbits.

The abstraction of *series* from *nexus* runs deeply in Linnaean natural history, as it is related to the distinction of genealogically determined species and environmentally determined varieties that formed the backbone of his taxonomic research program (Müller-Wille, 2003). But why should that abstraction be historically important? Because it did bring to the fore, in the long run, regulation, to use Canguilhem's expressions once more, as a "triumph over instability, a recovery after degradation" rather than a latent and implicit rule. This sounds inconsistent, because Linnaeus seemed to cling to regulation as a latent rule, after all. But it becomes evident as soon as one realizes, how exactly *series* and *nexus* relate to each other. The separation of *series* and *nexus*, of organic reproduction *per se*, that is, and an environment providing the means for reproduction, inserts a deep gap of contingency into Linnaeus's natural history. It is not the "station" or the place in the economy of nature that an organism occupies, which also produces it. Rather organisms happen to reproduce and multiply *themselves* at exactly that rate which ensures that they eventually also fill up all the places that happen to serve their needs in a continually expanding, geographic space. Linnaeus Garden of Eden is an orgy in contingency. Full-grown individuals — not seminal principles, forms or the like — placed in their little, fully equipped households, so to speak, and instantly beginning to have intercourse and multiply at exactly that rate that goes along with the assumed growth of the habitable earth.

Geography, Stratigraphy, and the Tree of Life

Linnaeus's distinction of *series* and *nexus* is intimately linked with the rise of two intertwined, biological concepts in the eighteenth century: reproduction and heredity. As Hans-Jörg Rheinberger and myself have argued elsewhere, this epochal shift was due to a mobilization of early modern life. Only when organisms, including humans, were actually removed from their natural and (agri-)cultural habitats, could heritable traits manifest themselves against a background of environmental change. Such mobilization occurred with increased intensity in a variety of social arenas during the early modern period: new varieties of plants and animals were bred for specific, marketable characteristics; botanists exchanged specimens among botanical and zoological gardens; experiments in fertilization and hybridization of geographically separated plants and animals were carried out by gardeners and naturalists; colonialism was accompanied by global dislocations of European and African populations; new social strata, with their particular pathologies, appeared in the context of industrialisation and urbanization (Müller-Wille, Rheinberger, 2012).

In spite of its naïve reifications, Linnaeus's theory therefore reflected quite closely the research interests of its time. Correspondingly, it was very successful in instituting a research program, as both Egerton (1973), and more recently, James Larson (1994) have shown. As much as Linnaeus's economy of nature severed the diversity of species from the variety of "stations" and "habitats" they occupy, declaring both to be utterly contingent upon each other, as much were the quest for the so called "natural system" of species and genera on the one hand, and the mapping of the geographical and stratigraphical distribution of organisms on the other pursued independently of (though concurrently with) each other. Two hypotheses, which Linnaeus had derived from his theory of a growing, habitable earth, thus soon broke down: First, that the same species of plants and animals would be found, at their respective stations, on the same geographical latitude around the globe (Müller-Wille, 2005); and secondly, that fossils would turn out to represent nothing else but dead specimens of still living species.

It is especially François Jacob, who has stressed the immense importance of these two developments: the scale of nature was shattered, as well as the close relation believed to exist between organisms and the habitats they occupy. Life forms were found to scatter over time and space in a way that bore no apparent relation whatsoever to the variation of physical factors in time and space. Probably the best indicator of this change is the acceptance, in the later eighteenth century by people like James Hutton (1726–1797) and Georges Cuvier (1769–1832), of the idea that fossils could be used as indicators of abstract, if not absolute, then at least relative geological time. According to Jacob, it was the capriciousness of such facts — "the dispersal of living forms, the breaks in time that created them, and the gratuity of variation" (Jacob, 1970, p. 174) – which nourished the theories of evolution that began to emerge around 1800. To avoid the organicist connotations that always go along with the notion of "evolution", one might characterize the change around 1800 by saying that at that point in the history of the life sciences all organicist cosmology finally, and irreversibly, gave way to what can be termed stratigraphic or tectonic cosmologies.

It is in this context that the concept of regulation should become more and more explicit in the various branches of natural history, yet not as an intrinsic principle consisting in a permanent balance between antagonistic forces, and instituting states of perfect adaptation, but as an extrinsic principle governing adaptation as a process of regaining balance again and again and instituting transient states of an utterly instable balance. This was a curious, and very fundamental inversion: ***the balance of nature turned from a permanent process into a transient state of affairs, while adaptation turned from a transient state of affairs into a permanent process***.

I would like to illustrate this change by taking a look at an influential, pre-Darwinian attempt at theorizing empirical results from natural history research: Charles Lyell's theory of centers of creation. Lyell's three volume book *Principles of Geology* (1830–1833), in spite of what its title might suggest to a reader today, was a comprehensive synthesis of all fields of late eighteenth and early nineteenth century natural history. Thus it included extended discussions of various previous attempts to account for the biogeographical distribution and geological succession of species by invoking processes of species transformation through hybridisation (Linnaeus), climatic degeneration (Buffon), or some inherent developmental tendency (Lamarck). Although Lyell was critical of all of these attempts to explain species transformation, one can consider his *Principles of Geology* as the major pre-Darwinian synthesis of natural history, a "geology" in the most literal sense (Rudwick, 1970).

Lyell identified the "parcelling out of the globe amongst different nations [...] of plants and animals" as the main problem to be tackled by any theory of organic diversity. Yes, he regarded it as a "[universal] phenomenon so extraordinary and unexpected" as to be "one of the most interesting facts clearly established by the advance of modern science". All the more, he found it of "primary importance" to look for "laws which regulate [the] geographical distribution of [species]." (Lyell, 1832, vol. 2, p. 66). In searching for such a law of regulation, he took the following approach:

"[L]et us inquire whether we can substitute some hypothesis as simple as that of Linnaeus, to which the phenomena now ascertained in regard to the distribution both of aquatic and terrestrial species may be referred. The following may, perhaps, be reconcilable with known facts: each species may have had its origin in a single pair, or individual, where an individual was sufficient, and may have been created in succession at such times and in such places as to enable them to multiply and endure for an appointed period, and occupy an appointed space on the globe" (Lyell, 1832, p. 124).

This passage evinces that Lyell took Linnaeus's theory of the increase of the habitable earth seriously, while it also exposes the decisive point in which the former deviated from the latter. In contrast to Linnaeus, Lyell does not assume that the several reproduction rates of species, their "powers of diffusion", were exactly proportioned to each other from the very beginning to achieve a universal and eternal balance. He rather assumes that each species, on its own and independently of all the others, was allotted its particular "power of diffusion" and was held within certain limits by barriers, obstacles, and the "endless vicissitudes of the inanimate" in general (Lyell, 1832, p. 20). As these limitations operate variously in space and time, creating particular contexts leading to the expansion, dimunition, or even extermination of species, they allow to account for the seemingly capricious distribution of species in time and space. As Lyell put it, e. g., for the case of extermination:

"[T]he addition of any new species, or the permanent numerical increase of one previously established, must always be attended either by the local extermination or the numerical decrease of some other species" (Lyell, 1832, p. 142).

Reproduction rates, that is, may differ over time, depending on changes in the local environment of a species, and, what is more, they are not fine-tuned in exact proportion to the one specific habitat only that this species occupies. If that were so, one species would not be able to exterminate another, each species would be a "monopolizer" of its specific habitat, as Lyell once put it (Lyell, 1832, p. 131), and as each species is, as a matter of fact, in Linnaeus theory. Lyell formulated this principle of differential reproduction in an awkward, paradoxically sounding, but unambiguous way:

"It is clear that if the agency of inorganic causes be uniform as we have supposed, they must operate very irregularly on the state of organic beings, so that the rate according to which these will change in particular regions will not be equal in equal periods of times" (Lyell, 1832, p. 160).

Lyell is invoking the principle of uniformity here, according to which one must assume the same physical and chemical processes to have occurred on the surface of the earth in the past as in the present. The source of organic diversity can therefore not lie in these processes alone. It is rather the fact that each kind of organism reacts *specifically* to given environmental conditions that introduces an element of variation. The prime example adduced by Lyell for this source of instability is man, and he concludes his argument with a reference to recent human history, followed by a bold and sweeping generalization:

"Yet, if we wield the sword of extermination as we advance, we have no reason to repine at the havoc committed, nor to fancy, with the Scotch poet, that 'we violate the social union of nature' <…>. We have only to reflect, that in thus obtaining possession of the earth by conquest, and defending our acquisitions by force, we exercise no exclusive prerogative. Every species which has spread itself from a small point over a wide area, must, in like manner, have marked its progress by the diminution, or the entire extirpation, of some other <…>" (Lyell, 1832, p. 156).

This formulation was probably as near as Lyell could get to Darwin's theory of natural selection. And indeed, there is a pre-*Origin* work by Darwin himself, which was clearly Lyellian in character and that constituted a major step towards Darwin's theory of natural selection: his *Structure and Distribution of the Coral Reefs* (1842) (MacLeod, Rehbock, 1994). This book comprises what one could call a natural experiment by which Lyell's hypotheses could be "tested".[12] The distribution and structure of coral reefs corresponds to the geographical distribution of species, and is controlled by two single, exactly determined factors: change in water depth and the growth rate of corals. Regulation occurs here in a true feed-back loop: water depth regulates coral growth; coral growth regulates water depth. In a kind of thought experiment, Darwin explains, from particular constellations of these two, interrelated factors only, the duration, distribution and structure not only of living, but also of fossil coral reefs (Darwin, 1986, p. 103–105).

The importance of the coral reef work for Darwin's theorizing derives from two circumstances: Firstly, that in it Darwin clearly spelled out regulation as a relation between two factors, which, each taken in isolation, derive from independent causes — coral growth from polyp physiology; change of water depth from tectonic elevation or subsidence — and which are thus completely contingent upon each other. The regulatory function of each factor upon the other is explicitly invoked by Darwin (1986, p. 123) to explain the rare occurrences of stable situations in a vast sea of instable ones (Müller-Wille, 2009). Secondly, it is the coral reef which is probably the best illustration of what else is called the "tree of life:" corals do not only grow occasionally, but *must* grow at the expense of others, they grow on and overgrow each other, and the history of coral reefs is thus always a history of competitive struggle and, in the end, extermination.

Conclusion

For some concluding remarks, I would like to come back to Linnaeus. His theories of creation and the increase of the habitable earth derive their naïvity, their almost ridiculous character, not from the fact that Linnaeus was a believer in a preordained balance of nature. He shared this belief with countless thinkers since antiquity, and it does not strike me as a particularly naïve, although somehow superficial observation, that rabbits are not exterminated by birds, beasts, and men, because they proliferate in excess. The outrageous naïvity of the picture that Linnaeus drew of paradise derives from the fact that it invoked the institution of a perfect, stable order in a situation whose utter contingency is overtly recognizable. To repeat: In the Garden of Eden, as Linnaeus envisioned it, organic reproduction and the environment were separated by a deep gap of contingency. Later naturalists, by elaborating on this gap in pursuing paleontology, biogeography, and taxonomy as separate research agendas, invoked regulatory principles to account for the order that was observed to reign in the living world despite its contingency. Regulation as an explicit concept, I would therefore like to conclude, is not another expression for cosmic harmony, but a principle invoked were the contingent, the non-necessary reigns. It is therefore, and will remain, a biological (and, trivially, technological) principle *per se*.

[12] On Darwins's "experimentalism" see: Rheinberger, McLaughlin, 1984.

References

Bredekamp H. Darwins Korallen // Dingwelten. Das Museum als Erkenntnisort, Köln: Böhlau, 2005. S. 77–87.

Canguilhem G. Ideology and Rationality in the History of the Life Sciences. Cambridge, Mass.: MIT Press, 1988. 160 p.

Darwin C. The Geology of the Voyage of H.M.S. Beagle. Part I: Structure and Distribution of Coral Reefs / ed. by P.H. Barrett, R.B. Freeman (The Works of Charles Darwin. Vol. VII). New York: New York University Press, 1986. 248 p.

Egerton F.N. Changing Concepts of the Balance of Nature // The Quarterly Review of Biology. 1973. Vol. 48. P. 322–350.

Gregory A. Harvey, Aristotle and the Weather Cycle // Studies in the History and Philosophy of the Biological and Biomedical Sciences. 2001. Vol. 32. № 1. P. 153–168.

Harvey W. The Works of William Harvey. Translated from the Latin with a Life of the Author by Robert Willis. London: The Sydenham Society, 1847. 624 p.

Jacob F. La logique du vivant. Paris: Gallimard, 1970. 354 p.

Larson J.L. Interpreting Nature. The Science of Living Form from Linnaeus to Kant. Baltimore, London: John Hopkins University Press. 1994. 227 p.

Limoges C. Introduction // C. Linné. L' équilibre de la nature. Paris: Vrin, 1972. P. 7–24.

Linné C. von. Oeconomia naturae [Diss., Resp. I. J. Biberg] // Caroli Linnaei Ammoenitates academicae, seu Dissertationes variae Physicae, Medicae, Botanicae antehac seorsim editae. Erlangae: Jo. Jacobus Palm, 1749/1787. P. 2–58.

Linné C. von. Transmutatio Frumentorum [Diss., Resp. B. Hornborg] // Caroli Linnaei Ammoenitates academicae, seu Dissertationes variae Physicae, Medicae, Botanicae antehac seorsim editae. Erlangae: Jo. Jacobus Palm, 1757/1788. P. 106–119.

Linné C. von. Politia naturae [Diss., Resp. H.C.D. Wilcke] // Caroli Linnaei Ammoenitates academicae, seu Dissertationes variae Physicae, Medicae, Botanicae antehac seorsim editae. Holmiae: Salvius, 1760/1764. P. 17–39.

Lyell C. Principles of Geology, Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation. 3 vols. London: John Murray, 1832.

MacLeod R., Rehbock P.F. (eds.) Darwin's Laboratory: Evolutionary Theory and Natural History in the Pacific. Honolulu: University of Hawai'i Press, 1994. 540 p.

Mauss M. Essai sur le don. Forme et raison de l'échange dans les sociétés archaïques // Sociologie et anthropologie. Paris: Quadrige/PUF, 1997. P. 145–283.

Müller-Wille S. Gardens of Paradise // Endeavour. 2001. Vol. 25. № 2. P. 49–54.

Müller-Wille S. Joining Lapland and the Topinambes in flourishing Holland: Center and periphery in Linnaean botany // Science in Context. 2003. Vol. 16. № 4. P. 461–488.

Müller-Wille S. Walnuts at Hudson Bay, Coral Reefs in Gotland: The Colonialism of Linnaean Botany // Colonial Botany. Science, Commerce, and Politics in the Early Modern World / ed. by L. Schiebinger and C. Swan. Philadelphia: University of Pennsylvania Press. 2005. P. 34–48.

Müller-Wille S. The Dark Side of Evolution: Caprice, Deceit, Redundancy // History and Philosophy of the Life Sciences. 2009. Vol. 31. № 2. P. 183–200.

Müller-Wille S., Rheinberger H.-J. A Cultural History of Heredity. Chicago: University of Chicago Press, 2012. 323 p.

Rheinberger H.-J. Buffon: Zeit, Veränderung und Geschichte // History and Philosophy of the Life Sciences. 1990. Vol. 12. P. 203–223.

Rheinberger H.-J., McLaughlin P. Darwin's Experimental Natural History // Journal of the History of Biology. 1984. Vol. 17. № 3. P. 345–368.

Rudwick M.J.S. The Strategy of Lyell's Principles of Geology // Isis. 1970. Vol. 61. № 1. P. 4–33.

Spary E.C. Political, Natural and Bodily Economics // Cultures of Natural History / ed. by N. Jardine, J.A. Secord, E.C. Spary. Cambridge: Cambridge University Press, 1996. P. 38–56.

Экономия природы в классической естественной истории

Штафан Мюллер-Вилле

Университет Экзетера, Экзетер, Великобритания;
S.E.W.Mueller-Wille@exeter.ac.uk

Хотя в связи с изменением содержания понятия «экономии природы» произошло одно из наиболее фундаментальных концептуальных изменений в науках о жизни, оно в значительной степени осталось незамеченным. В период расцвета этой концепции в XVIII в. считалось, что экономия природы регулируется вечными законами, которые гарантируют устойчивое равновесие. Гибель и появление новых особей, так соразмеряются друг с другом, что место каждого отдельного погибшего организма занимает другой, идентичный предыдущему по своей природе. Как подчеркнул в своём труде «Логика живого» (Logique du vivant) (1970) Франсуа Жакоб, в силу целого ряда событий на рубеже XVIII–XIX вв. существовавшие ранее представления о стабильном соотношений между живыми организмами в их различных формах и местами их обитания были поколеблены. Взаимосвязанное развитие систематики, биогеографии и стратиграфии привело к выявлению вероятностного характера взаимоотношений между строением организма и окружающей средой, распалась жёсткая связь между историей жизни на Земле и историей самой Земли. Наконец, дарвинизм понимает «экономию природы» таким образом, что живые организмы занимают те места, которые ранее населяли другие формы жизни, т. е. новые формы вытесняют предшественников. Равновесие в природе стало восприниматься как принципиально неустойчивое состояние, а соотношения между живыми организмами — как по своей природе непропорциональные. В настоящей статье я постараюсь проследить этот концептуальный сдвиг от «Экономии природы» Карла Линнея (1749) через «Принципы геологии» (1830–1833) Лайеля к сочинению Чарльза Дарвина «Строение и распределение коралловых рифов» (1842).

Ключевые слова: регуляция, история экологии, Карл Линней, Чарльз Лайель, Чарльз Дарвин.