

**The Cumulative Action of Creation**  
A Calculus Under Darwin



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## 1. THE BEGINNING

Darwin's observations of life did not square with the old model of organic development, the "sudden" and "inexplicable...creation of species from the dust of the earth" (2.15.362<sup>1</sup>). He found flux instead of fixity. He found that the "differences" between organisms "blend into each other by an insensible series" and "impress the mind with the idea of an actual passage" (1.2.53). This pushed him towards the idea that creation was and is a continuous process, a never-ending calculus where "every complex structure and instinct" in nature is the "sum...of many contrivances" (1.14.474).

How seriously can we consider a "calculus" of creatures? How does it operate and what is the evidence for it? Can we superimpose principles from mathematics onto physical reality? Does Darwin even ask us to? Maybe not, but life's "insensible steps," (1.6.190) its countless "series of gradations," (1.6.203) its continuous "sum[mation]" invoke such a comparison. Moreover, Darwin and Leibniz employ the same Latin phrase in their separate studies: *Natura non facit saltum*. Nature makes no leaps. Though Darwin calls this principle an "old canon in natural history," it is often directly attributed to Leibniz (5.16<sup>2</sup>). Might this convince us that a calculus of life is implicit in *Origin*?

Darwin uses "*Natura non facit Saltum*" to substantiate another major principle of continuous creation: "nature is prodigal in variety, but niggard in innovation" (1.6.194). Both can be considered a reformulation of Leibniz's "law of continuity," that "[e]quality [is] a particular case of inequality, rest [is] a special case of motion, parallelism [is] a case of convergence" (7.546). How do these seemingly dissimilar laws say the same thing? "Equality and the circle

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<sup>1</sup> Citation Format for Darwin: (citation #, chapter, page)

<sup>2</sup> Citation Format for Other Authors: (citation #, page)

terminate the motions” of inequalities and polygons, just as organic dissimilarity terminates in similarity, organic variability terminates in stability, varieties terminate in species, and ancestral forms terminate in current ones (7.546). One merges into the other by “insensible gradations,” ruled by the same mathematical or organic “innovation.” Thus, we may link the disparate images of geometry, physics, and the entire landscape of life. We may wonder, however, whether mathematical continuity is comparable to natural continuity.

If creature calculus is an appropriate analogy, it might clarify some of the questions which *Origin* poses. Could it make the nebulous terms of classification clear? Maybe, if we discovered a way to measure organic difference and we confirmed its continuity, we could calculate some species “rate of change” across time. Since “specific characteristics are more variable,” we could use a derivative of organic difference to substantiate new species (1.5.155). We could quantify classificatory terms: locating periods of accelerated variability followed by plateaus of self-sameness. Alternatively, we could sum all the ways an organism transformed in time and argue that at some particular threshold a new species or genus, for example, was merited. We could integrate difference or Darwin’s “principle of divergence” over a certain period and look for organisms which evolve most assiduously or struggle most severely (1.4.113). We could compare the integrated difference of polymorphic genera, for example, with those that rarely vary. We might even see trends.

Evolutionary calculus may be illuminating but it immediately raises issues. What should its independent axis be, time or space? What about its dependent axis, organic difference or divergence? Darwin assures us that life diverges and that divergent species are preserved. They spread, supplant the places of inferior forms, and inevitably prevail. Can we use prevalence,

dominance, and life-span to measure which organisms have changed the most? How can we be sure these are actually correlated and not falsely equated with divergence? An algebra of organisms reveals latent problems in the logic of *Origin*. When analyzed, its evidence appears to dissolve, its variables to evaporate. We discover a disturbing amount of self-fulfilling circularity.

Still, Darwin's case taken in its entirety seems credible. By accumulating the effects of three simple and universal laws, he arrives at the primrose and the pigeon, the honey bee and the hinny. He explains the entire organic spectrum. Darwin goes further still, forever solidifying his status as the Copernicus of biology. He weaves together beings separate in both space and time, into one system that extends all the way back to The Beginning. Darwin poses a contemporary but uncomplicated null hypothesis, captured in the phrase: *Natura non facit saltum*.

## 2. THE THEORY

### A. The Principles

Throughout the first four chapters, Darwin acclimates his audience to three main principles of evolution, which we must deem "at least possible," to proceed (1.int.6). The first law needs no confirmation: organisms possess a "strong principle of inheritance" (1.int.7). Parents look like children, something consistent binds families together. Pigeons only make more pigeons, something constant underlies life's continuous development. The second law, that "a large amount of hereditary modification is at least possible," does require proof (1.int.6). Darwin does not expect us to accept this and move on, like a mathematician might. He works to convince us that variability exists and that all organisms are potentially alterable. Is the first law's tendency to preservation overruled by second law's deviations of character? Not according to Darwin, the first is persistent, the second intermittent. Even the "tendency to variability is in itself hereditary" (1.4.120). The third law says that the pressures of survival "select" the most

successful organisms. They keep the population in check, eliminate unhelpful adaptations, and preserve those that promote longevity. Together, these three elements activate the “manufactory of species” (1.2.58).

To convince us of his second law, Darwin must prove that variation occurs naturally. He first asks us to consider the “endless slight peculiarities which distinguish the individuals of the same species” (1.1.26). This is easy but his next request is more difficult: imagine these small differences gathering in one organ as it grows evermore distinct. Further, imagine this organ increasing in utility across time, for natural selection will always weed out the adaptations that hurt its host’s chances and “accumulate” those that help (1.2.47). We may wonder whether Nature “accumulates” figuratively or literally, like man does. Might natural and artificial selection “sum” in different ways? Does either operate at an infinitesimal level or an incremental level? If their steps are insensible how do we spot them? How does Nature seize them? If they are sensible can evolution be continuous? Might Nature make leaps?

Before we can properly analyze the function of evolution, we must verify that all life is potentially variable. Darwin first tells us that domestic variation is “not hypothetical.” Its evidence is everywhere, “compare the host of agricultural, culinary, orchard, and flower-garden races of plants” (1.1.32). Some naturalists deny its universality, claiming “man has chosen” creatures with an “extraordinary inherent tendency to vary” (1.1.19). This is statistically improbable, given the number of life forms we could have tamed instead. Others argue that we do not choose alterable organisms but that our custody activates their capacity for change. This idea contains two implications: first, that only domestic creatures vary; second, that only man can effectively accumulate adaptations. Darwin refutes the first outright: “variability...is not

directly produced” by man. He “can neither originate varieties nor prevent their occurrence; he can only preserve and accumulate such as do occur” (1.4.82). He cannot will new traits into being, just as the organism does not vary by “volition” (1.1.14). The second idea is more subtle: it requires a side by side comparison of natural and artificial selection.

While tamed types “generally differ more from each other than” those “in a state of nature,” the distinction exists in the “degree” of difference between the two and not the “manner” (1.1.18). The manner of action is the same because selective forces operate everywhere. While it may be challenging to imagine Nature “selecting,” we must simply recall that “every being” follows the “principle of geometrical increase.” Since more organisms “are produced than can possibly survive,” (1.3.73) each must endure the “war of nature, [of] famine and death” (1.14.478). Comparatively, domestic productions have it easy. Man “does not allow the most vigorous males to struggle for the females; he does not rigidly destroy all inferior animals, but protects” all (1.4.84). Nature is a far more vicious master, her “selective” forces may be figurative but they are fierce. So why do man’s productions differ more?

Man often “begins his selection” with a “half-monstrous form.” He chooses “modification[s] prominent enough to catch the eye” (1.4.85). He selects for obvious, even artistic differences, but his powers are limited to “externally visible” traits (1.1.40). Nature, meanwhile, operates on every aspect of the organism, inside and out. Her choices are subtle, almost infinitesimal. Yet, she keeps her eye on the prize: her end is survival “of the individual” and “success in leaving progeny” (1.3.65). In comparison, man’s choices seem overt and incremental, his ends superfluous. In the interim, artificial selection may appear more pronounced. In the end, the whims of man prove always weaker than the winds of time.

Domestic productions do not all vary to the same “degree.” If “two forms vary, which already differ” their “variability will not be of the same exact nature” and “the results obtained through natural selection...will not be the same” (2.6.192). The speed and direction of an organism’s evolution exists along an infinite spectrum of possibilities, depending on its tendency to variation and the power and preferences of whoever selects. Should we explain each speed separately? No, each adaptive rate reveals a sliver of Nature’s “prodigal...variety” and scant “innovation” (1.6.194). Darwin unifies the proportional difference between domestic and wild variation, then all the sub-degrees of each (1.4.82). His three laws also tell us that selection cannot occur unless variations arise. If all life shows the effects of selection, then all life must be susceptible to adaptation.

Can we reinforce this reasoning with evidence? We may take breeders at their word that “they can model almost as they please” their “plastic” subjects but how do we prove wild plasticity? (1.1.32) Darwin recounts numerous cases where “highly competent judges” cannot agree whether organisms are varieties or species (1.2.51). Since, “[t]here is no possible test but individual opinion to determine which of them shall be considered as species and which as varieties,” (2.2.48) these terms become “a mere useless abstraction” (2.2.50). The nonexistent consensus around naturalism’s most fundamental terms suggests that the science of life has gone awry. If physicists could not agree on meters, for example, how could their findings be shared, compared, or understood? How could we assure ourselves that distance was preserved in space and across time? The pervasiveness of these conflicts hints that organisms may be indeterminate.

Finally, Darwin reminds us of his guiding principle: *Natura non facit saltum*. While other naturalists “universally” use “the element of descent...in ranking together the sexes, ages,

dimorphic forms, and acknowledged varieties of the same species,” they cut the chain abruptly (1.13.446). They ignore nature’s lack of innovation, “[admitting] variation as a vera causa in one case” and “arbitrarily [rejecting] it in another” (1.14.470). Darwin applies the law of continuity to Nature’s machine. Though species, varieties, and individual differences may seem disjointed, they are time-lapsed pictures of an always unfolding process. Envision an organ, trait, or habit growing progressively stranger in time, always inherited, selected for or eliminated by struggle. Then “sum” the “many inherited changes...passed [through] successive adaptations” (1.6.193). We arrive at distinct species by adding up a few or more of these summed traits.

The three laws of evolution, taken individually, appear benign but their additive powers know no limit. Evolutionary integration slides from simple organs to complex innovations. In that most “inimitable contrivance” the eye, we find “much graduated diversity in...crustaceans” (6.186,187). Even the honey bee’s “perfect” hive can be explained by a natural progression. We shift from the humble bee’s “separate and very irregular rounded cells” (1.7.223) to the *Melipona*’s “nearly regular...cylindrical cells;” (1.7.224) to the hive-bee, each cell a “hexagonal prism” (1.7.223). Using these and other transitional gradations, we glide from simple organs to seemingly inexplicable organic inventions. Darwin implies that as long as intermediate forms are plausible, anything is possible.

## B. Lamarck

Darwin was not alone in this idea. Other authors demanded a continuous look at the earth’s history. In “modern geology,” Sir Charles Lyell’s observations led to the revolutionary conclusion that “great [valleys]” were not excavated “by a single diluvial wave” but, instead, by slow and continuous degradation (1.4.96). In the organic world, Jean-Baptiste Lamarck was the



“first...[to excite] much attention” to the idea that “all species, including man, are descended from other species.” He held that “all [organic] change” was “the result of law...not of miraculous interposition” (2.Historical Sketch.4-5). Why did these other authors, particularly Lamarck, fade into the backdrop? What made *Origin* so groundbreaking?

There are many points of similarity between Darwin and Lamarck. Both men outline a “real chain” of organisms, though Lamarck discusses it in the “opposite direction from that of Nature” (4.12). He describes organic convergence: organs becoming “progressively simplified...altered, reduced, and attenuated little by little” (4.10). Darwin describes the inverse phenomenon with his “principle of divergence” (1.4.113). Both ways of envisioning life ultimately lead to the same understanding.

Distant creatures can be linked together but what makes them distant to begin with? Lamarck tells us that the smooth and graduated line of life becomes warped as it “sustains anomalies...brought about by the influence of living conditions and of acquired habits” (4.11). Here we see his essential point of departure. Though Darwin admits the environment has “some slight and direct effect,” he cites many cases opposed to this doctrine (1.4.87). For it is “preposterous to account for [the mistletoe]” with habit or environment, since this parasite critically depends on “other trees” for nourishment, “certain insects” for pollination, “certain birds” for seed dispersal, and so on (1.int.5). The “demonstrative case of neuter insects” deals Lamarck another blow: the “peculiar habits...of the sterile females...could not possibly affect the males and fertile females” (1.7.240).

Darwin’s tendency towards divergence seems, at first, no different from Nature’s innate direction. Upon closer examination, we see that Lamarck’s chain is not purely spatial, temporal,

or even mathematical, but teleological. According to him, Nature's directionality and her "divine order" reveal an "innate and inevitable tendency towards perfection" (2.4.126). Darwin, on the other hand, finds "no limit to the amount of profitable diversification of structure" (2.4.129). Further, he ties organisms' gradual complexification to competition, not to abstract tendencies or ideal limits. This allows him to explain what Lamarck cannot, why "a multitude of the lowest forms still exist" (2.4.126).

Selective forces run the show in *Origin*, not fate. To make sense of life's chain, Lamarck portrays Nature as striving always towards perfection. Darwin substantiates his series in time and space, using the laws of evolution. Nature's art is an end for Lamarck, it is a never-ending experience for Darwin.

### 3. DIFFICULTIES

#### A. The Species

Life's insensible changes and "cumulative action" blur the boundary between one type of being and another (2.2.52). This necessitates that naturalists only "[know] vaguely what...a species" is (1.2.47). They seemed trapped by organic indeterminacy, forced to use terms which have no shared meaning. Can we rescue the word species from oblivion, from emptiness? Darwin does not try to, for a reason.

Species have significant flexibility, they contain ranges of being. Might the elastic edges of selfhood conceal an essentially simple character at the center? Maybe, except life's flexibility is not a symptom of sloppy language but of evolutionary integration. Continuity clashes with the idea of distinct organic quanta. Their dissonance only grows amplified. Though naturalists have found "several interesting lines of argument" to pinpoint species, like "geographical distribution, analogical variation, hybridism...[n]o one definition" of species "has satisfied" them all (1.2.47).

It is notable that almost every description involves the analysis of two or more organisms. We cannot classify in isolation. We compare the ranges and sizes of two closely related creatures: “If a variety were to...exceed in numbers the parent species, it would then rank as the species, and the species as the variety” (1.2.55). We employ systematic affinity or “the general resemblance between species in structure and constitution” (1.8.253). Comparison lets us factor out relative variability and tells us whether forms deviate to a typical or atypical degree. Yet, this relativity is also troublesome. If we cannot move beyond it to a general measure of divergence, then a calculus which combines all of life will remain impossible.

While Darwin dismisses many of these definitions, he explores the idea that “the fertility of” varieties “is...of equal importance with the sterility of species” (1.8.243). Many other naturalists uphold that mongrels, the offspring of two varieties, are far easier to cross than hybrids, the offspring of two species. Once again, this is a comparative definition. Unlike the previous ones, it has two clear benefits. First, it makes sense. Two physically unique creatures should not successfully reproduce; there are no elephant-bears or beetle-frogs. By extension, we could postulate: the more similar two organisms are, the more probable their likelihood of procreation. Second, we can test this determinant and our postulate on sexual creatures which reproduce in captivity.

Like many elements of life, fertility exists in “graduated steps, from slightly lessened fertility to absolute sterility” (1.8.262). This continuum may correspond to the graduated steps of similarity between species and varieties. This seeming symmetry, however, lets us “argue in a circle” (1.8.264). To naturalists who want species to be sterile, a single case of two varieties reproducing is fertility and anything less than the ideal output is sterility. They confirm what they

already conflate: similarity and sexual viability. If we found another way to verify species and their sterility coincidentally held, the spectrum between complete sterility and ideal fertility would offer one way to measure difference. We could cross two varieties repeatedly and take the average size of their litter, then divide that by the average sized litter of the same variety crossed. We arrive at a fraction which approximates similarity. This evidence-based definition of species does not resolve life's relativity but it may solve its indeterminacy.

The "fraction of similarity" starts to fall apart as Darwin floods us with case after case that defies this "broad and clear distinction" (1.9.243). For example, "when yellow and white varieties" of *Verbascum* were "crossed with yellow and white varieties of a DISTINCT species, more seed [was] produced by the species crosses between the similarly coloured flowers, than between those...[of] differently coloured" varieties (1.8.267). Even "distinct genera" can be successfully crossed, as the "common and Chinese geese" together "[raise] no less than eight hybrids" (1.8.250). Might these exceptions be falsely ranked? The more prolific the examples, the less probable that seems. Darwin tells us the idea that species are "invariably sterile and varieties invariably fertile...cannot be maintained" (2.15.520). The rule holds "general[ly]" but not "universal[ly]" (1.8.251) and "harmonizes perfectly with the view that there is no essential distinction between" species and varieties (1.8.271).

The insensible summation of life has destroyed the sanctity of classification. Darwin gives us no clear concept of what a species is. He admits "varieties cannot be distinguished from species--except, first, by the discovery of intermediate linking forms; and, secondly, by a certain indefinite amount of difference between them" (1.2.60). The first is contingent, the second unqualified. In most cases, the status of an organism is determined by a "majority of naturalists"

(1.2.50). But the “old saying of Vox populi, vox Dei” meaning the voice of the people is the voice of God “cannot be trusted in science” (2.6.179). Reason must always rule. We have no clue how to catch all individuals of the same type, without accidentally including others. We cannot tell whether two different species are simply short-lived transformations of the same identity. Moreover, nature’s “prodigality” assures us that any rough standard of species-sameness will differ across organisms and across characteristics.

### B. The Tautologies

Naturalists often “argue in a circle” about the characteristics that connect and distinguish varieties. Recall the forced fertility definition above, how scientists strain the facts to fit their terms (1.8.264). The apparent symmetry between the spectrum of fertility and of similarity tempts us to equate them without evidence: varieties graduate into species as fertility graduates into sterility. Not only is this inherently circular, this parallelism does not strictly hold. Slippery symmetries like this one almost invite us to apply the law of continuity and unify causality, to claim that species and sterility are variations of the same innovation. Does this overestimate Nature’s simplicity? Or might this symmetry be substantiated? Maybe, but we cannot test the fertility fraction until we find another way to gauge organic similarity.

Likewise, some naturalists claim that “important organs never vary,” but then they “rank those parts as important...which do not vary” (1.2.48). Some trait is significant if it has classificatory importance, it is inessential otherwise. Their “evidence” only confirms their expectations. Darwin calls out these self-fulfilling solutions to the species question. Does he succumb to the same kind of fallacy? Does he equate his assumptions with his conclusions, his proofs with his premises? Yes and no. He connects important organs and ones that vary but

evades the same circularity by reversing the principle: “the less any part of the organization is concerned with special habits, the more important it becomes for classification” (1.12.405).

Darwin differentiates himself from other authors by citing the laws of evolution before introducing classificatory evidence. For example, since embryos are rarely self-sufficient, they maintain “structures which are of no service” and delay the development of special adaptations (1.13.429). All mature forms must become specialized to survive but highly-dependent embryos can afford to be late bloomers. Thus, early life forms though entirely “[un]concerned with special habits” often present the primitive traits of their progenitors. While other naturalists start with assumptions and find what confirms them, Darwin’s leans towards facts and careful inference before he offers evidence. He escapes circularity by building his system on solid ground.

Other tautologies lurk within *Origin*, however. Without a way of sorting species, we use common or constant traits to connect organisms and inconsistent traits to separate them. We presume that a trait which is “still variable...[has] recently varied and thus come to differ” (1.5.169). We define varieties using current variation, species using recent variation, and so on, each higher taxon gaining stability. Yet, the average rate of variation fluctuates wildly across all different organisms, there is an infinite spectrum of these speeds. There’s no consistency, no standard generic rate of change that lets us guess how long ago a genus varied or how much it should be changing now. Without a solid system, we get that creeping sense that a circle may be forming: varieties varied recently because they diverged recently. We find Darwin’s essential “principle of divergence.”

Organic difference can mean a million things, it is non-directional, a scalar quantity. Divergence is vector-like, it is always in relation. It points away and towards, above and below,

another creature. It implies a destination. Towards what? What does it mean to be more or less divergent? Although, “it is hardly possible to define clearly what is meant by organisation being higher or lower” in the scale of nature “no one probably will dispute that the butterfly is higher than the caterpillar” (1.13.431). Yet, divergence is not synonymous with maturity: in “certain parasitic crustaceans...the mature animal cannot be called higher than its larva (1.13.431).

In general, organisms “higher in the scale” of nature express a greater amount of “organization...differentiation and specialisation” (1.4.135). Specialized organs are those “[set] apart...for the performance of a particular function” (1.Gloss.493). Divergence translates to specialization, specialized organs to divergent forms. Darwin also tells us that Herbert Spencer’s expression “Survival of the Fittest” is “more accurate” and “sometimes equally convenient” as his own, “natural selection” (2.3.70). Both ideas, the first more bluntly, tell us that those who survive are well-adapted or divergent and that “diversified...descendants” survive being “better enabled to seize on many and widely diversified places” (1.4.113). The circle widens, one term after the next is both defined by and the definition of divergence.

Say we could compare the population size and spread of an extinct creature with a living descendant and ask: why did one prevail? All we have is the futile argument that it was more specialized, more divergent, more suited to survival. We could point to an intricate organ or developed trait as “proof,” but we could probably find one of these in the extinct organism, too. We could say it was better adapted but we could not say why. “[W]e are much too ignorant...to say what slight modifications” are “[important]” or successful (1.6.194).

Let us not underestimate Darwin by dismissing the principle altogether. We need real proof, which he tries to provide. Consider how diversely “[s]eeds are disseminated” from “their

capsule being converted into a light balloon-like envelope, by being embedded in pulp or flesh...by having hooks and grapnels of many kinds and serrated awns...and by being furnished with wings and plumes...to be wafted by every breeze.” How do we explain this “inexhaustible number of contrivances” without invoking the Creator or the principle of divergence? (2.6.191) Even if we lack an explanation of our own, we can still point out the logical flaw implicit in this argument. Nature may display great diversity now but this is not grounds enough to call organic divergence an eternal tendency, a law of life.

Chapter Four is riddled with other arguments that may give weight to this empty word. I have isolated a few I find compelling. Darwin echoes other naturalists in the idea that the ecology of nature is akin to the ecology of an individual, that both optimize “physiological division of labour.” A stomach which digests “flesh alone, draws most nutriment from” it, just as a specialized organism may draw most benefit from one place in nature’s polity (1.4.116). However, “physiological division of labour” is another loose term that tells us nothing about what divergence is or how we can measure it. We might as well say specialization. Further, a stomach is not a species, a unified body is not the battleground of nature. Development in one does not necessitate development in the other.

Next, we confront two tests of divergence. Though we may “[expect] that the plants which...[become] naturalised in any land would generally have been closely allied to the indigenes...the case is very different” (1.4.115). Instead, we find that new and unrelated genera often gain ground. Darwin claims that since they are divergent, they easily seize the niches of the natives. We could perform an experiment by introducing many organisms to a confined island. Distinct genera should survive more often than the genera closely resembling the indigenous.



Similarly, in “any small spot...more living beings can be supported on the same area the more they diverge in structure, habits, and constitution” (1.4.130). Another experiment emerges, we count the number of creatures and the number of genera which cloak an area. If there are more living beings, there should be more diverse genera.

Are these experiments circular? Even if our hypotheses are confirmed, these may be false correlations, caused by some other factor than divergence. Moreover, these experiments are set up to numerically verify our expectations. We do not analyze the nature of the organisms which survive, the nature of the island or area we test, we do not look beyond our principle. Let’s say we do try them, we then gather up the organisms which become naturalized or grow successfully then ask: what do they have in common? Or, why did they survive? The answer “because they are divergent” is not good enough. Over many trials, we could try to find the traits, organs, or habits that all the winners share, then call this divergence. As our sample size grew, the list of shared features would most likely shrink. This trend would then tempt us back towards divergence, for this hollow term catches almost any kind of commonality. Yet, these and other experiments will not always confirm Darwin’s principle: the “most divergent varieties,” do not invariably “prevail and multiply” (1.4.121).

Finally, “extinct beings...are often, in some degree, intermediate in character between existing groups” (1.4.127). Simply imagine life’s convergence against time and this fact makes sense. Convergence is just the inverse of divergence. We cannot use its potential explanation of classification as a proof of its existence. It is convenient but not conclusive. This is a theme buried within each argument above and throughout *Origin* as a whole. Darwin finds phenomena explained by divergence, then uses it as evidence for divergence. For example, the tree of life is

difficult to unsee. It grows roots, ingratiates itself into our understanding, and becomes the basis for other assertions. We then recycle those assertions to prove the picture. Almost unintentionally, it becomes a demonstration, no longer a hypothetical depiction meant to “aid us” in this “rather perplexing subject” (1.4.117). We might wonder, are all the images which science gives us - the tree of life, the periodic table, the plum-pudding model of the atom - empty proofs? Can we extricate them from our unconscious, without replacing them with new pictures?

What happens when evidence conflicts with this picture? Darwin goes out of his way to interpret the many proofs against evolution. The geological record, for example, presents very few transitional varieties. He explains this fact away so doggedly, however, that we blame paleontology instead of evolution. In similar ways, Darwin softens many facts that are hostile to his theory. He integrates the honeybees hive, the inimitable eye, and the numerous “castes” of ant neuters, among many others, into his expansive rationale of evolution (1.7.236). Is there one fact that could dissolve Darwin’s complex case for continuous creation?

Darwin’s diagram goes along with many series and many symmetries throughout Origin that show us one way to organize the wild: his way. The more we look for proof of any one, the more we find latent divergence. Struggle, specialization, success, and survival, for example, are four different paths to the same essential circle: divergence with time, convergence against it. What argument could liberate us from this loop? Is there one fact that could solidify evolution? Might a real tree made of documented fossils and living forms do? Would we still doubt whether intermediary forms existed in the space between? Might we force organisms into the role of transitional grades, citing analogical variations or other false positives? Might we, in our eagerness to prove evolution, even fabricate connections between unrelated forms?

#### 4. THE SOLUTION

##### A. The Natural System

Darwin blurs the line between slight and significant organic differences. He tells us that nature is not made of species “beings” but species “becomings.” If species are time-sensitive slices of a never-ending evolutionary process, why is not all life “an inextricable chaos of varying and intermediate forms?” (1.6.177) Why do we even try to separate, group, and arrange the spectrum of organisms? We dare to order Nature because she is not in constant mutiny.

There are many reasons why “nature [is not] in confusion,” why “species, as we see them” appear “well defined” (1.6.172). First, we have confidence in these chimerical terms of classification because, relative to our conception of time, life does not change (1.6.178). At least it does not change significantly enough for us to be alarmed. Nature’s changes are “insensible” and do not occur all at once. At any given time, a limited number of forms will have their capacity for alteration activated. A breeder’s changes may be more noticeable but, try as he might, he cannot produce a brand new animal.

The second reason species seem clear and distinct is that barriers may once have stood where they stand no longer. For example, certain bodies of land may have merged after millenia of existing as separate islands (1.6.178). Similarly, valleys might have risen. Mountains might have worn away. Seas, rivers, or lakes might have grown connected in recent millenia. These old and now invisible boundaries, if they existed, would have “not only [separated] but [formed] the several” distinct “zoological and botanical provinces” around the world (1.12.399). Third, on long continuous land formations “intermediate varieties [form] in intermediate zones.” These narrow zones sustain limited populations, which are less likely to vary and are liable “to

accidental extermination” (1.6.178). Thus, intervening forms are often eliminated before we notice them. Lastly, the “very process of natural selection constantly tends” to supplant “the parent form” (1.6.179). Extinction makes the boundaries of each being even sharper.

These forces slice apart organic series into unified groups. Species are perceptible; we can point them out. Are they persistent? Classification suggests as much. Terms like species demand that we limit nature’s constant motion at a static endpoint of adequate difference. Darwin does not demand this but neither does he dismiss taxonomy. Instead, he extends organic continuity beyond “sexes, ages, dimorphic forms, and acknowledged varieties” into breeds, species, genera, and so on (1.13.446). These are all transitional, temporary results of life’s perpetual recreation, unified by the “vera causa of community of descent” (1.5.160). Darwin ruins classification with continuity but redeems it with ancestral connection. The Natural System does not merely “[arrange] together those living objects which are most alike, and...most unlike” (1.13.404). Instead, it unites the present and the past, ties living forms to fossil remains. Despite their apparent disagreement, classification actually helps us define the dimensions of creature calculus: time and the traits that bind all living beings.

Might the Natural System’s incremental tiers of life be akin to the Periodic Table? Linnaeus remarks in *Philosophia Botanica* that “the characters do not make the genus, but...the genus gives the characters” (1.13.405). In a similar way, Mendeleev says “[t]he *magnitude* of the atomic weight determines the properties of the element” (8.406). The weights on the Table, the terms of the System are more than convenient, they reveal a “deeper bond...than mere” numerical or visible “resemblance” (1.13.405). These identities then fuel the furtherance of each science. For example, by linking two seemingly separate genera to the same family, we start to see their

affinity. This formerly unseen affinity brings another genus into the family, and so forth. Likewise, the vertical axis of Mendeleev's Table "corresponds to the *valence*" or "the number of bonds that element can make when it forms compounds" (8.405). Valence dictates "chemical behavior," so we can test whether similarly-shelled "B, C, N, O, F" react in the same way when exposed to some other element (8.405). Yet again, we might wonder: do these methods of sorting restrict our sight? Once seen, we abandon our search for other illuminating images, for other dimensions of connection which they cannot account for. They drill themselves into reality, they shape all future inquiry. Could the pictures of science indoctrinate us?

### B. Time

If we accept that ancestry underlies life's insensible progression, we may combine the natural series which surround us in space with series in time. For example, the "almost perfect series" of pigeons we see now might be conceived chronologically: time elapsed since each form split from the ancestral rock pigeon (1.1.29). Temporal and spatial chains recur throughout *Origin*: "Let two forms have not a single character in common, yet, if these extreme forms are connected together by a chain of intermediate groups" their relation becomes incontestable (1.13.417). Darwin reveals the latent logic behind our natural ordering systems and tells us the two ways of envisioning life are ultimately the same. A lineage is simply a chain of creatures with an axis that tells time.

Time could be the independent variable of evolutionary calculus. It makes organic series meaningful by revealing ancestral connection. Space offers another option. It provides the boundaries of organic "provinces," it lets us know that two species have not crossed paths for a significant amount of time (1.12.399). Although, space is spotty and unreliable. We cannot say

what the earth looked like when a fossil was formed, sometimes we cannot be sure where it was formed. For the “geological record” presents “a history of the world imperfectly kept and written in a changing dialect” (1.9.305). Time seems to be a more stable variable.

Time gives the calculus meaning. If some organism showed a linear or geometric rate of change, might we extrapolate backwards and “age” all beings living and extinct? In an ideal world, but Darwin does not anticipate such regularity (1.4.121). Organisms do not “[undergo] change through some innate law” (2.4.107). We might never be able to reverse engineer the convergence of life into the one or “few forms...originally breathed by the Creator,” but with actual data before us, like a series of fossils or of current forms, we could develop evidence-based quantities of difference (1.14.478). After collecting millions of data points, we might find correlative patterns, however weak or unbelievably complex. We might find an association between some organic kind and its rate of divergence, or its level of complexity and its integrated difference. With these, if they exist, we could start approximating life’s origins.

In a similar way, Darwin extends evolution beyond all comprehension. He applies the concept of organic continuity *continuously*, towards the idea “that all animals and plants are descended from some one prototype” (1.14.471). This lone analogy summarizes *Origin* in its entirety, it carries *Natura non facit saltum* to its logical conclusion. It also tells us that Darwin’s theory tilts one way in time. We may look into the past, using the clues Nature has planted beneath the earth’s crust, but not into the future. “[N]o man can predict” Nature’s prospective plans (1.4.128).

The terms of taxonomy may have arbitrary edges but they have actual significance. They estimate how long ago two organisms diverged from a common ancestor. We circle back to the

unanswered tautology. Might organic progressions in space and their sequence in time present another false symmetry? Evolutionary calculus offers a potential solution to this problem. What if we discovered some absolute method of discriminating between species: some single characteristic or set of them, a test, or other measure of sufficient difference? With this measure we could mathematically link organisms together. We could prove sterility starts at species. We could confirm the principle of divergence or prove that diversified forms typically survive. We could prove that life's series in time and space are the same. An evidence-based calculus could destroy the circularity at the center of *Origin*.

What could this measure of sufficient difference be? All previous measures of difference have been comparative and approximate, restricted in scope to two forms. Without a universal metric, we cannot link together all life within one calculus. How do we escape this relativity? Say we could list all potentially variable organic traits, habits, functions, and create a separate scale for each one which measured the entire continuum of its complexity; say we could weigh each of these against its importance, dependent always on the organism which hosts it; then sum all these numbers. Presumably, each individual would have its own unique sum. Although this method demands serious progress in naturalism, it does not seem strictly impossible.

### C. The Unit

Such a project would be as immense as its implications would be. Let us consider the practicalities of this analytical approach. We already have an independent variable. Our dependent variable is easy to grasp but harder to gauge: organic change. Before we figure out how to measure it, we need to know *what* we are measuring: the physical objects of our observation. It is too overwhelming to analyze all life at once. Should we model different

functions for every community, every genus, or every species? We do not know what species are. How will we know what changes to look for if we do not know where to look?

The endless action of evolution has sabotaged all previous definitions of species. Instead of finding species by comparing statistics, affinities, or single attributes, might we use evolution's fundamental principles in our favor? Any proper object of evolution will be ruled by all three laws. While all living beings pass on traits and are potentially alterable, not all organisms struggle against one another.

Darwin assures us "natural selection cannot...modify the structure of one species, without giving it any advantage, for the good of another species." He insists there is not one "case [of altruism] which will bear investigation" (1.4.88). This implies he has sought proof to contradict this principle, not merely to corroborate it. Selfishness gives us our first arguably non-tautologous, non-relational definition of the smallest element of evolution. If two organisms work against one another in any way, then they are not the same species. If one organism selflessly assists the survival of another, then they are the same species. A "unit" is concerned only with its own survival. Alternatively, a "unit" is what natural selection acts upon. Outside, the ruthless battle of life reigns. Inside, all is calm, collected, and secure.

While selflessness and selfishness seem like mutually exclusive options, they become blurred in the wild. One organism may help another while still helping itself enough to be self-serving. We have to weigh the energy expended against the benefit derived. What would it mean if we found that the first does not always offset the second? Would we prove altruism exists? Would we dismiss such exceptions by claiming they are fated for extinction? Or, would we change our "unit" of evolution?



Despite being Darwin's choice, species may not be the right "units" of evolutionary struggle. Is there cooperation outside of species? Is there competition within them? Yes, beings "most nearly related" experience the "most severe" competition (1.10.314). What could be more related than members of the same species? Varieties? Individual members of the same family? Where does Nature's rivalry begin and end? Who does She "select?"

At one extreme, we could consider the smallest increment of struggle. Beyond individuals, we might posit that characteristics compete. Might blue and yellow shades of primrose vie for prominence? Since they are singular, they have nothing to collaborate with. Or do they? "Correlated variation" says otherwise (1.5.146). "[M]any remarkable cases" show that "[c]olour and constitutional peculiarities go together" (2.1.22). In truth, the "whole organisation is so tied together...when slight variations in any one part occur...other parts become modified" (1.5.145). Since single traits can be said to work together, they cannot be our "units."

We might inch upwards. The different buds of a plant compete against one another for space, nutrients, and sun. But "separate flowers...can be considered as distinct individuals only in a limited sense" (1.4.100). Many plants, trees in particular, have a "strong tendency to bear flowers with separate sexes." Darwin labels the "intercrossing of distinct individuals of the same species" a "general law of good" breeding (1.4.100). In hermaphroditic plants, though the pollen and stigma of their flowers are "placed so close together, as if for the very purpose of self-fertilisation," they are "in so many cases mutually useless" (1.4.99). Lone flowers frequently do not struggle alone: they seek out sexual partners and prevent against self-fertilization.

Onwards, we shift our scope to individual organisms. Darwin often says that Nature selects the "best individuals" (1.1.38) and that individuals endure the struggle for existence

(1.3.63). Yet, what organism is truly independent? Family and community are often essential. Without them, we cannot explain why the bee stings, killing itself “by tearing out its viscera” (1.6.201). Even the “insuperable difficulty” which neuter insects create for Darwin’s theory, can be overcome if “selection may be applied to the family” (1.7.235). Sterile sister ants may determine whether their fertile siblings survive. The family, an extension of selfhood by relation, is one “serviceable end” of natural selection (1.7.235). If we isolate lone beings as evolutionary “units,” then we must admit altruism into the equation.

Interfamilial competition is also real: “the improved and modified descendants of a species will generally cause the extermination of the parent-species” (1.10.315). Of course, parent-species here means generations past. The idea holds: parents, siblings, even children are very “nearly related” and thus the competition between them is “severe” (1.10.314). What are they: loyal allies or lethal adversaries? It depends. There cannot be a one-size-fits-all “unit” of natural selection. We must consider the social or familial dependence of each species, calculating the cost of cooperation versus the profit on a case-by-case basis. If assisting the community is too “expensive,” then we must extend our “unit” beyond the individual.

Sexuality is another essential factor when scrutinizing an organism’s particular “unit.” Separated sexes are developed as an evolutionary advantage, as intercrossing is a “general law of good” breeding but they necessitate another dependency. Females seem to collude through sexual selection, together they “produce a marked effect...by selecting, during thousands of generations, the most melodious or beautiful males, according to their standard of beauty” (1.4.90). As Nature selects those best suited for survival, females select according to their strict ideas of beauty. We know that inconsistent choosiness accomplishes nothing: picture the

unspectacular result of a fickle pigeon fancier. The females of a population may be said to work as one but males certainly do not. How do females agree on aesthetic standards?

Sexual selection adds a new complexity to the calculus. It must account for ancestry and organic difference or divergence. Now, it must include beauty? Female tastes can align with nature's fitness, take male "weapons" or "means of defence." Yet, they also choose elaborate "charms," "antics," and "gorgeous plumage" (1.4.90). Such ostentation goes against nature's effort to "economise...every part of the organization" (1.5.148). Might these separate selective forces demand separate axes?

Might we still make a case for Darwin's locus of selfishness: the species? For some organisms, like corn and rape-seed, "a large stock of individuals...is absolutely necessary for its preservation" (1.3.72). Though "if several varieties...[are] sown together," some may "beat...and...supplant" all the others (1.3.77). Again, the "struggle for life is most severe between individuals and varieties of the same species" (1.3.62). The gradations of severity give us another symmetry: intensity of struggle and level of similarity. Competition decreases as we go above species into genera but it peaks somewhere between varieties and individuals. This peak points back towards individual organisms as the solo units of struggle. It appears impossible to gather the cooperative parts of Nature in one group, without catching her competitive side.

Unable to find the sweet-spot between the two, we might look towards the other extreme. We could call the community, the entire ecosystem, The One our organic "unit." Darwin tells us many times that when organisms "[migrate] in a body together, their mutual relations will not [be] much disturbed...[and they] will not [be] liable to much modification" (1.11.361). If some species is only stable because of its community, then is it itself outside it? If not, then organisms

that even indirectly interact must be grouped together. This idea ignores the “struggle” between similarly situated organisms. It falsely suggests comradery, cooperation, even altruism at all levels. How can we circumscribe one community as completely separate from another? Is Australia a “unit?” Do all oceans hold one creature? If life is an undifferentiated mass, how do we systematize it? As soon as the temperature changes or the land shifts, the self-stability of The One would be destroyed. Should we include the earth or the climate within our “unit?” No, this disturbs the obvious boundary between the inorganic and organic sciences.

Weighing all these options, the most viable object of evolution, for animals and many plants, seems to be a pair which possess both male and female sexual organs. It has its limitations: would we dare call a queen bee and a single drone a complete pair? What about neuters or asexual creatures? We might add neuters as long as they contribute something absolutely essential to a procreating pair, like childcare or labor. Finally, we have a functional “unit” of study. We could limit our observation to one child to prevent a geometric increase of subjects. As we gathered more and more of these graphs, we could prove or disprove ancestral connection by linking many. Obviously, a significant amount of time would be required to see any substantial change. Say we could, somehow, watch such a series over a million years. We could then begin the science of evolutionary integration.

## 5. THE CALCULUS

### A. The Independent Axis

A full analysis is not yet feasible. We have an object of creature calculus but not both axes. How do we calculate organic change across time? To link life together we need one ultimate metric of divergence, not a relational fraction or an organism-specific metric. To capture dissimilarity either numerically or graphically, we must measure all the many ways an organism

can vary. There are more than one or two dimensions of divergence and relation: “it is notoriously not possible to represent in a series, on a flat surface, the affinities” of organisms (1.13.413). We must account for all the qualities which differ in organisms, an unfathomable number of components that grows alongside our understanding. Should we seek similarity, instead? Would it be the direct inverse of dissimilarity or would it be easier to capture? The list of organic qualities which are exactly alike should be shorter than the unlike list, since a continuum of the second terminates in the first. Although, when we zoom in to examine whether two organisms are identical in some respect, we might just spot more differences.

Other formidable issues lie in wait. While some organic aspects have a built-in scale, like height or even eye color, how would we measure maternal instinct or the pattern on a peacock? These traits might, themselves, be multidimensional. Can they be decomposed into more basic elements? Can we reduce organic complexity into millions of one-dimensional traits?

Even if this were possible, we could not simply sum these different scales together. Can any one measure capture the infinite variety of expression? It seems we must invoke the nebulous terms diversity or complexity. How else could we accumulate them on the same axis? Maybe we could find a system that translates face shape and finger length, that decodes shades of scales and types of skin. How? What would we base this scale of significance on? What would be the organic form of Hydrogen, the “one” in terms of traits? Moreover, organic attributes are not created equal. Organs of high physiological importance often say very little about an organism’s origins while “rudimentary or atrophied organs” (1.13.405) and “generative organs...[afford] very clear indications of its true affinities” (1.13.407). Attributes which say more about ancestry must weigh more in our system.

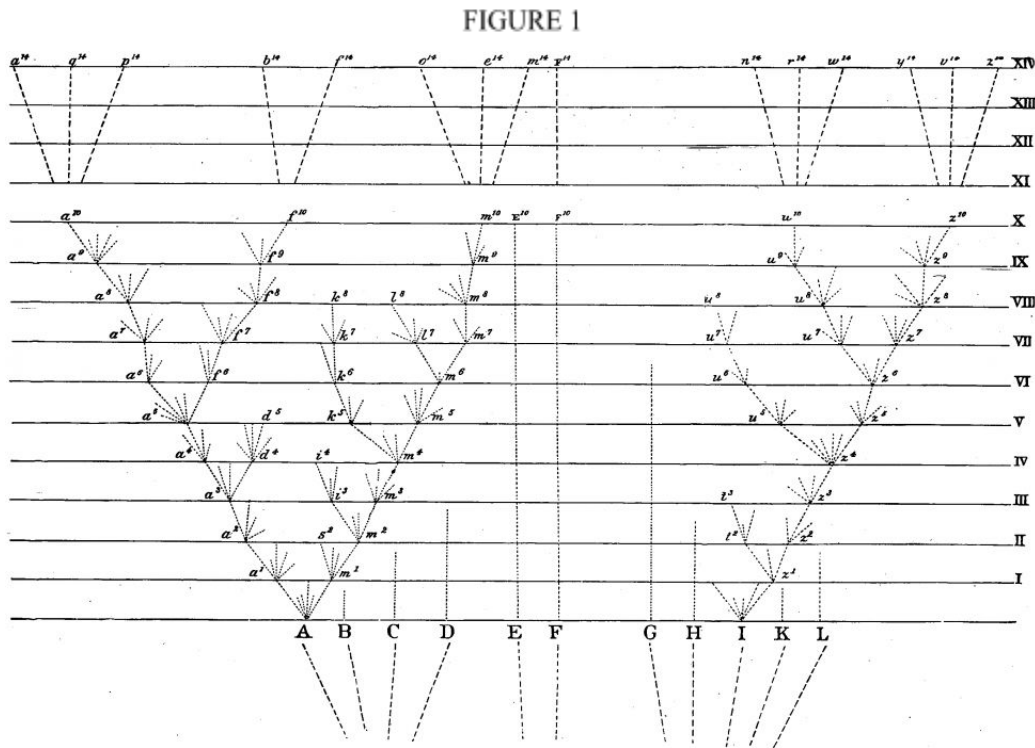
These difficulties suggest what Darwin confirms, that we will need to know “every form which has ever lived on this earth.” Only then is a natural arrangement “possible” (1.13.423). Similarly, any mathematical mapping of life composed in ignorance cannot be true. Varieties are “clustered like satellites around other species” (1.2.59). Skipping one form in the transcript of evolutionary history is akin to skipping one star in a solar system: its gravitational influence on nearby bodies goes unaccounted for. It is somewhat like skipping one element in the periodic table, though we may not as easily sense that something is missing. We cannot systematize life properly if our scope is restricted to current forms and scant fossils.

A full analysis of evolution appears impossible for many reasons. The infinite dimensionality of any mathematical difference metric is disheartening. Additionally, an accurate scale is contingent on pigs flying: the sudden reappearance of all past forms (1.13.423). Darwin opts for another measure: divergence. Divergence seems easier to capture as it is vector-like, meaning direct comparison between more than one data point. Yet, it brings us back around to organic relativity and, what is more troubling, the tautology at the center of *Origin*. It is inextricable from struggle, survival, and complexity. Using any of them to measure divergence leads us down dizzying circles that conceal this term’s emptiness. We cannot ground difference or divergence in anything which can be confirmed. Without them, the calculus appears hopeless.

Maybe Darwin knows what divergence is as well as “every naturalist knows vaguely what...a species” is (1.2.47). Unlike species, however, Darwin does not destroy divergence. He depends on it.

## B. The Diagram

Darwin's diagram avoids the infinite complexity and essential circularity of organic change. It suggests that he solves all the issues mentioned above. Has he? Does he find a way to approximate evolution or does he simply assume it exists and is measurable? The diagram raises another dilemma: the staggered, branching pattern conflicts with our image of life as a continuous process. Yet, it is reminiscent of the leaps in the System's terminology. Might the diagram reconcile the incompatible ideas of evolutionary calculus and classification?



Darwin's axes are slightly different from those used in our calculus (Figure 1). The vertical axis keeps time but in undefined and alterable units. Numerals I through XIV may each denote "a thousand...a million or more generations" (1.4.120). Alternatively, they may represent "a section of the successive strata of the earth's crust" (1.4.120). The flexibility Darwin gives

these units is powerful, it tells us that the same pattern can map the progress of any taxon. The horizontal axis measures difference or similarity, following always “the principle of divergence” (1.4.113). In the diagram,  $a^1$  and  $m^1$  are not some C units apart along the x-axis merely for the sake of space. Species A and L “resemble each other in unequal degrees...as is represented in the diagram by the letters standing at unequal distances” (1.4.117).

Darwin’s diagram is illustrative of the principles and not particulars of evolution. He takes a lofty view of life, avoiding the issues of precise variable analysis. How does he avoid these issues? Does he invoke assumptions or evidence? Neither, Darwin references no facts or arguments but introduces the diagram as an “aid” (1.4.117). Again, it is helpful only if we treat it as a hypothetical depiction and not a demonstration. What does this “approximation” reveal about evolution? At  $T = I$ ,  $a^1$  branches out into 5 different lines. All but one ( $a^2$ ) peters off into extinction. Suddenly, at  $T = II$  five new species spring from  $a^2$ . Does this mean descendants die out gradually but arrive instantaneously? Do new species surface regularly, at complete intervals of  $T$ ? Darwin does not resolve the first question here, but assures us species “are not supposed to appear simultaneously” or “regularly.” The “breaks” in the diagram “are imaginary” (1.4.121).

Nature does not unveil species in a linear or geometric series or all at once. The abruptness of this diagram speaks to something which creature calculus cannot: life is not continuous. Organisms do not clone themselves instantaneously or perpetually, reproduction takes time. Sexual creatures also inherit characteristics from two sources. The mother’s traits meet a set of foreign ones. The child “leaps” from both parents, a discontinuous combination. Further, adaptations “suddenly” arise (1.1.31). Of course they do. Their suddenness lets breeders spot and select them. Might their suddenness be apparent, a symptom of our limited sight? Might



man be blind to extremely slight increments of organic change? Or, might life have a smallest possible step of change? What would this organic “quantum leap” represent?

There is evidently something sensible about Darwin’s “insensible series.” Do species surface instantaneously, just like adaptations and individuals? We might hope that discontinuity could mend the discord between the calculus and classification. Darwin disillusioned us. A new species does not suddenly emerge every time a new individual is born or a new trait appears. In fact, new species do not emerge suddenly at all. “[I]f a single individual” is born with a modification that gives it “twice as good a chance of life...this chance would go on decreasing in the succeeding generations.” Instead, “this result” only “[follows] from the preservation during many generations of a large number of individuals” who express the same alteration (2.4.76). A lone form, however extreme, can not single-handedly create a species. Nature does not “leap,” she sums many micro-adjustments over millions of years. It is strange that chance variations must recur repeatedly, almost systematically, throughout a species for an organism to evolve. This seems to contradict the very idea of “chance” variation.

In light of life’s slight discontinuities, we swap a smooth curve conception of evolution for a staircase function. Are there grounds to reject our guiding principle: *Natura non facit saltum*? Not necessarily, the gaps between parent and child, between one trait and the next are incomparably smaller than the discontinuity which creation demands. They are extremely slight in the grand scope of evolution. By increasing our time increments and adding more data points, we can roughly smooth life’s leaps and imagine it as a curve.

This returns us to a much earlier question. Is mathematical continuity akin to natural continuity? There are jumps in organisms and organic traits just as there are jumps in physics.

What exists between the elements on the periodic table? Isotopes do but not along a continuous series. The leaps in the periodic table may be an early form of the fact that atoms are quantized. We still treat chemistry and physics as mathematically sound sciences. Though organisms too, are inherently incremental, they can be considered as approximately continuous and differentiable when we take a step back. The facts of life are messier than a mathematician might like but the price of continuity need not destroy the promise of creature calculus. The infinite dimensions of complexity and the nonexistence of divergence, however, just might.

### C. Prediction

Even if we abandon creature calculus, we need not think that some other mathematization of life is impossible. We still have a “unit” and one axis. Yet, other issues with organic analysis emerge when we probe the diagram. The first appears when we posthumously label fossils. Say at  $T = 14$  we unearth specimen  $a^5$  and place it accurately in line with its ancestors and descendants (Figure 1). This form connects  $a^{14}$ ,  $q^{14}$ ,  $p^{14}$ ,  $b^{14}$  and  $f^{14}$ . Let them together constitute a distinct genus called  $\beta$ . Does  $a^5$  belong to  $\beta$ ? This would be a prospective and not retrospective name, running counter to the direction of evolution. Since  $a^5$ ,  $d^5$ ,  $k^5$ , and  $m^5$  all emerged from ancestor A, they might comprise their own genus  $\gamma$ . But then A gives rise to two genera,  $\beta$  and  $\gamma$ , one nested inside the other. Enclosing one genus inside a category of the same size defeats the purpose of having tiers of organization. Further, this internal origami ignores that each organism will expire, that the terms cannot be eternal. We could graduate genus  $\gamma$  to a family, its species to a genus, its family to an order, and so on. Yet, this means a new species name for something that no longer lives and a new taxon beyond Kingdom. While linearity of descent renders this

procedure appropriate, Darwin confirms that all “raising or sinking the value of the groups...has hitherto been arbitrary” (1.13.419).

Of course names are not mathematical, still this hypothetical shows that every newly unearthed fossil, every newly unveiled form entails a cascade of edits to our tree. We cannot leave space in our diagram for new forms, like Mendeleev could in his table. We can locate general areas in the tree that seem sparse, but we cannot say what old forms are “missing” or where exactly new fossils belong. Naturalists cannot construct an end-all-be-all taxonomic order, a Mendeleev-like table with predictive capacity, nor an organic algebra which can extrapolate. Can we rightfully call a science “scientific” if it can only analyze the past?

Although, there are predictive aspects of *Origin*. Can we know what new forms will manifest next? It is difficult to say. To say that variability is entirely “due to chance” is a “wholly incorrect expression” (1.5.133). Our ignorance in this matter is staggering but Darwin outlines some probabilistic elements of adaptation. “[S]pecies which are the most numerous in individuals have the best chance of producing favourable variations” (1.4.110). Occasional intercrossing, large and open areas, and a “change in the conditions of life” all “[afford] a better chance of the occurrence of profitable variations” (1.4.83). We might guess which forms will vary, though we cannot say how they will. Additionally, we know that traits must recur to gain traction. One extreme form changes nothing. We could conceivably spot popular tendencies early on, then predict which will persist. Like the “Virginia squatters...[who] select the black members” of their pig litters, breeders can typically tell which animals or plants have a “good chance of living” (2.1.26). We may even estimate the speed at which a new species will become well-defined, factoring in the area they occupy, their population size, and the number of barriers.

There is one added complication of prediction yet unconsidered: the “infinitely complex relations” of organisms (1.3.63). “Throw up a handful of feathers, and all fall to the ground according to definite laws; but how simple is the problem where each shall fall compared to that of the action and reaction of the innumerable plants and animals which have determined, in the course of centuries, the proportional numbers and kinds of trees” (1.3.77). For, “the presence of a feline animal...might determine, through the intervention first of mice and then of bees, the frequency of certain flowers in that district” (1.3.76). These creature chains, one form determining the fate of the next, extend infinitely outward. One organism’s outcome cannot be calculated outside this chain. We may find a way to analyze life in isolated bursts but community prediction brings our difficulties to a climax.

We might be able to predict, at least, the rough shape of the tree: all its branches ascend up and stretch open. Although, there are many cases which disobey the principle of divergence. Darwin does not mention them when discussing the diagram but they recur throughout *Origin*. When two related species “vary in an analogous manner” they approach an “intermediate form” (1.5.162). Similarly, concurrent species can sometimes successfully combine. Yet, the diagram shows no merging branches. Nor do we see any branches that retrace their path, though species may “to a large extent, or even wholly, revert to the wild aboriginal stock” (1.1.17). While “the balance of evidence is opposed to” the idea of “the same form...recurring” years after extinction, this need not occur for us to be puzzled by potential but incomplete convergence (2.4.129).

The tree only stretches outwards and forwards, never inward or backward. It strictly depicts divergence, despite the fact that the organic spectrum intertwines in time. An individual may both approach and recede from its relations, mudding the boundaries between one form and

any other. This fact and the infinitely complex chains of interaction make a veritable maze of life. Darwin doubts whether we will ever “disentangle the inextricable web of affinities” that tie living beings together (1.13.424). Yet, in this disheartening admission, lies a clue. That life may, after all, look nothing like a tree but a winding, twisted “web.”

## 6. THE END

### A. The Limit

There may be another way to make life a prospective science. Darwin tells us that “Natural selection tends...to make each organic being as perfect as, or slightly more perfect than” its competitors (1.6.201). Maybe perfection is life’s limit, an endpoint where all its motion and change suddenly stops. Might Lamarck have been right, in this respect? If so, would this limit be sudden or might species drift smoothly towards it in an asymptotic fashion? Might organisms tend separately towards different ceilings, might The One do so altogether? If evolution does end, will we know it has once it is “perfect?”

The loaded word perfect comes from the Latin word *perficere* meaning “completed, excellent, accomplished, exquisite.” We may imagine organic excellence as something virtuous or harmonious: collective perfection. Yet, this ignores that the individuals who survive are selfish, that selection is a vicious marathon. Walking past a “tangled bank, clothed with all kinds of plants, birds singing...insects flitting,” we are overcome by beauty. Nevertheless, this peaceful scene depicts the “war of nature, [of] famine and death” (1.14.478). The grueling game of evolution follows no code of ethics.

A perfect outcome may suggest that Nature takes the “right” path. This could mean two things: first, that every living being has a preassigned course; second, that completing this course is “correct.” Darwin implies that embryos are born with all the information they require but

unlike Lamarck he does not suggest they have a guiding telos. He “believe[s]” that “the cause [of variability] may have acted...on one or both parents before the act of generation” (1.2.49). Darwin also labels it a law of “highest importance in...embryology” that “at whatever period of life a peculiarity first appears, it tends to reappear in the offspring at a corresponding age” (1.1.16). Living beings develop behavior, anatomy, adaptations, and even diseases in a precise sequence. Might organisms “know” exactly what to actualize and when? Darwin seems to think along the lines of Driesch, that “true epigenesis...does exist. One thing is formed ‘after’ the other; there is not a mere ‘unfolding’ of what visibly existed already” (3.28). Nature’s maturation may be destined but this does not render it right or wrong. A moral qualification like the second implication has no place in *Origin*.

Finally, we reach the limit. Perfection may mean a species is finished changing, has manifested its optimum self. Darwin tells us the opposite, that “[n]atural selection will not produce absolute perfection” (1.6.201). Yet, he also says in the case of the honey bee’s hive that “natural selection could not lead...[b]eyond this stage of perfection in architecture.” For “mathematicians [tell us] that bees have practically solved a recondite problem,” they maximize storage volume and minimize wax (1.7.233). The honey bee manifests his hive at the precise moment of architectural optimization. If future bees found a completely new and improved storage system, the honeycomb’s perfection would fall flat. Besides, this is only one of the honey bee’s perfectable traits. What about all the others? Its “success...may be dependent on the number of its enemies, or parasites, or on quite distinct causes, and so be altogether independent of the quantity of honey” it collects (1.7.232). This a highly limited case of perfection which

does not ensure survival. An “ideal” organism would be excellent in every aspect. Natural Selection pushes each creature towards this better version but “will not produce” it (1.6.201).

Further, perfection is often a matter of relation. Two species are “modified and adapted in the most perfect manner to each other” (1.4.96). For “Natural selection tends only to make each organic being as perfect as, or slightly more perfect than,” other beings (1.6.201). One organism’s perfection is dependent or determined by its competitor, cooperator, or companion. It may have one perfect relationship, a million imperfect ones. When any relationship changes, in any of the complex ways it can, then the ideal shifts. Thus, there are an infinite number of sub-limits of perfection, which develop parametrically between one or more always changing organisms. Perfection evolves, too. It would not arise from the calculus, like an asymptote.

Does Darwin’s association of perfection with the process of natural selection rely on evidence or the same kind of circularity that variability and importance did? How could we measure it? Perfection may be a rhetorical tool. Darwin must explain a number of incredible natural contrivances. Acclimating us to a “natural limit” helps us get there. “Perfection” also falls intuitively from a climate of intense competition. When one conflict ends, another follows. Each separate trial demands a different array of optimal characteristics. Yet, this resorts to the cyclical “Survival of the Fittest” logic (2.3.70). Reason reinforces this loop, does reality? Might the eye or honeycomb be evidence enough? If not, how many instances of subjective perfection would?

Perfection gestures toward three potential assumptions: cooperation, correctness, and completion. But all these attributes stem more from individual, metaphysical assumptions about the universe than from identifiable facts or fragments of Darwin. Though we may conceivably stretch the calculus back to The Beginning, we have no right to extrapolate to its End.

## B. Conclusion

Many serious problems still plague creature calculus. Numerous tautologies and unfathomable complexities obscure the idea of organic change. Ancestry and variability, species-hood and sterility, struggle and success, competition and cooperation, perfection and selection, difference and divergence dizzy us throughout Darwin's argument. Creature calculus could prove these are not rhetorical fallacies but real phenomena. If they were, even their circularity would make sense. Only then would their conflation be due to a "true" symmetry, being two varieties of one fundamental innovation.

However, the calculus hinges on finding a determinant metric of difference or divergence. If difference could be measured, we could substantiate divergence. Yet, the first has too many components to calculate, the second is empty without proof of the first. Without difference we need divergence, and so on. This is the most daunting circle so far. Where do we look for relief?

Maybe, we can look to other scientific laws. We cannot prove Leibniz's Conservation of Vis Viva, the idea that the "same quantity [of force] is always maintained though it may be carried by different bodies" (6.7). "For not all truths about bodily things can be derived from logical and geometrical axioms...[or] concepts that are exemplified in sense-experience." Force belongs to the class of concepts that are "perceptible only to the mind and not through the senses" (6.7). Might we also claim that divergence is not sensible but seeable? That it is a fact of the universe just like force? Yet, mathematical physics feels more solid than the organic sciences, maybe even incontestable. What is the alternative to accepting force? The laws of life are messier, more liable to misinterpretation, multiple theories seem simultaneously plausible.



It appears we cannot know, prior to observation, that life tends towards divergence across time but we also cannot show it without assuming it first. For only then does its “evidence” become apparent. *Origin* asks us to take a side, to weigh instantaneous against continuous creation, to ask ourselves: which of these fits the facts better? Which one explains more of the inexplicable; which is more durable in the face of new discovery; which requires fewer caveats and relies on fewer causes?

When we put aside the circularity and press forward into the logic of evolution, Darwin’s grand argument grows on us. He berates us with many cases, many curious questions, many references to long and dry catalogues. There is no single argument which legitimizes Natural Selection. Darwin’s observations, evidence, and sometimes even experiments accumulate into something compelling. There are countless continua. In space, organisms can be linked in a line, like pigeons (1.1.29). In time, ancestor and descendant show a fine series of gradations. On the micro level, we see series in organic traits and habits, like the hives of bees (1.7.223). On the macro level, large classes only show commonality when connected in a chain, like crustaceans (1.6.186). The existence of these separate series seems too uncanny to be a coincidence. Might one fundamental innovation underlie them all? This is only one aspect of Darwin’s numerous arguments. Like drops in a bucket, they gather, grow, and graduate into something substantial.

Maybe a calculus of creation cannot be fully pursued, maybe it can. But outside the difficulties of difference, something else feels wrong with organic algebra. A purely mathematical analysis of evolution cannot measure up to reality. The Amazon and the Great Barrier Reef are far more than the sum of their parts; they exhibit properties which no one

individual can mimic. Could we synthesize separate functions into one ultimate organic history? Must any organic function ignore the effects of interaction and interdependence?

The idea that life, forever pouring forth, could be condensed into single variables is pleasing but it may make plain our hollow conceit. Will we ever be able to analyze Nature's power, potential, or prospects? Or does that question undermine the incomprehensibility of Her reign? We may suppose that Nature is too disordered to orchestrate this kind of dynamic creation without divine instructions or guiding functions. But are we too fixated on human-centric notions of intelligence, to see the genius beneath Her motions? Darwin asks "[h]ave we any right to assume that the Creator works by intellectual powers like those of man?" (1.6.188). Might the same be said of Nature? We may well impose a guiding figure or grasp for algebraic figures out of fear, fear that the "wild" holds within it an inexplicable kind of knowledge, one that vastly outstrips our own.

Even so, Darwin's dogged pursuit of truth is what makes *Origin* so powerful. He was not daunted by someone else's disbelief. Staring down his "profound ignorance," he still sought to untangle the web-like affinities of life (1.i.8). We might take a page from his book: leap from one series to the next, continually move from one picture to a more improved version, until we too, can approximate the past and present state of natural perfection.

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