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Decadent Dinosaurs: Paleontology and Directed Evolution in British and North American Literature, 1890s–1970s

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Abstract: Despite paying concerted attention to evolutionary mechanisms, literary scholars have rarely focused on forms of “directed evolution” like orthogenesis (evolution along a linear track) and phylogeronty (the parallel between the lifespan of an animal group and the lifespan of an ageing individual). These analogical concepts represented a paleontological manifestation of wider interest in human decadence. I analyze their exploration in three areas: popular adventure fiction, social reform novels by Marie Stopes and H. G. Wells, and writings by paleontologists. Across these texts, I argue that directed evolution was used to give a recognizable trajectory to prehistoric and modern life alike, turning certain extinct animals into moral exemplars of evolutionary failure. While reformers hoped that humans could escape the orthogenetic grooves confining nonhuman animals to extinction, this optimism was shadowed both with fears that humans might inevitably face decadence and with a sense that survival meant mediocrity.

In her 1951 book *A Land*, British prehistorian Jacquetta Hawkes reflected on a “merciless force in evolution” that caused “trends, once they have begun, to become excessive and at last pathological.” Her example was the fork-horned Miocene deer *Synthetoceras* (figure 1), which “must have looked more ridiculous than Munchausen’s stag with a cherry tree sprouting from its forehead; it is not surprising that it found life intolerable and rapidly became extinct” (29). While Baron Munchausen’s claim to have produced a tree-horned stag by shooting it with cherry stones was notoriously dubious, nature, Hawkes implied, could produce comparable monstrosities. Her understanding of the “ridiculous” horn drew upon two influential paleontological concepts: orthogenesis (evolution along a linear track) and phylogeronty (the parallel between the lifespan of an animal group and the lifespan of an ageing individual). In short, *Synthetoceras*’s aberrant horn, an overly specialized structure unfitted to its environment, was a sign of the genus’s evolutionary old age. Other groups purportedly trapped in senescent evolutionary trends were “luxurious forms of life” (79) like the armored dinosaur *Stegosaurus* and the “bizarre and decadent” ammonites (81).

This article explores the heyday of these suggestive concepts in British and North American science writing and fiction. To this end I will group orthogenesis and phylogeronty, along with recapitulation (the belief that growing animal embryos rapidly re-enact their own evolutionary histories), under the umbrella term “directed evolution.” In this I follow Warren D. Allmon (2020: 424), who carefully distinguishes “*patterns* in the history of life” from “views of the *processes* of evolution.” While the identification of the former is a descriptive affair, the imposition of the latter, with which this article is concerned, is explanatory. Allmon observes that, for many paleontologists who examined trends like the evolution of increasingly spectacular horns, “recognition of the seemingly ubiquitous *pattern* frequently slid without comment into acceptance of the *process*” (441). As the slippage suggests, directed evolutionary hypotheses leant on metaphor and analogy, chiefly the analogy of the life cycle: youth, maturity, senility. Orthogeneticist geologist Herbert Leader Hawkins remarked in 1920 that “[t]he analogy is too perfect to be the outcome of mere coincidence or sophistry; it is an expression of the simplicity and order that are fundamental attributes of the Universal Cosmos” (118). Paleontologists also compared the inertial evolution of non-adaptive traits to the decadence of the Roman Empire (Swinton 1934: 179), the screeching brakes on the London Underground (Swinton 1966: 117), and even the disconsolate final movement of Pyotr Ilyich Tchaikovsky’s Symphony No. 6 (Hawkins 1920: 117).

Charles Darwin famously struggled to portray natural selection as non-teleological (Beer 2009: 76), but, for naturalists skeptical about the importance of selectionism in generating species, teleological or at least directional analogies were critical. Devin Griffiths (2016: 18) distinguishes “*formal analogies*” that “apply a previously understood pattern of relationships to a new context” from “*harmonic analogies*” that “allow significant shared features to emerge.” Unlike the bilateral harmonic analogies Griffiths sees as central to Darwin’s insights on the origin of species, such as the comparison between domestic and wild breeding (34), the analogy between the individual life cycle and that of the animal group was a formal superimposition of the former onto the latter, explaining evolutionary trends through a ready-made model. As already indicated by the mention of Rome, this ostensibly naturalistic analogy often included a cultural value-judgement, comparing waning genera to decadent civilizations. While the notion of cycles of civilizational decadence is usually considered a metaphor of natural life cycles applied to human culture, Whitney Davis (2005: 138), against the grain, contends that “decadence is really a metaphor of Culture applied to Nature.” This is the case in the most pungent writing on directed evolution, in which the persistent maladaptation of animal groups indicated an unconscious but quasi-moral failure.

Directed evolution, which was gradually excluded from mainstream anglophone paleontology in the decades following the 1940s, has long been the subject of scholarship by historians of science (Manias 2017), especially Peter J. Bowler (1989). Scholars of twentieth-century literature have paid it less attention, despite an increase in literary work on non-Darwinian evolutionary theory. For example, intense interest in Darwinism (Greenberg 2009) has been accompanied by literary research on theories that downplayed the importance of natural and sexual selection like neo-Lamarckism (Hale 2006), Hugo de Vries's mutation theory (Endersby 2013), and Henri Bergson's vitalism (Moses 2014). Paleontology and especially directed evolution have usually been only passing subjects of analysis in this work: Cathryn Setz (2019: 62–75), for instance, briefly explores James Joyce's irreverent treatment of orthogenesis in early versions of *Finnegans Wake* (1939), while several scholars have examined Virginia Woolf's interest in evolutionary specialization and embryonic recapitulation (Chan 2014: 174; Livingstone 2022: 151–95). I will return to Woolf at the end, but for now it is enough to note that these avant-garde modernists usually undermined the deterministic assumptions key to directed evolutionism. As we shall see, the figures I will examine were typically drawn to its potential relevance in halting societal decline, while, unlike Joyce and Woolf, they expressed their thoughts in more traditional literary genres.

This ideological and stylistic conservatism may also explain why the currency of decadence in paleontological thought has not found a significant place in the growing body of work on literary decadence in the twentieth century (Hext and Murray 2019) or in relevant research on decadent ecology (Denisoff 2021) and decadent science generally (Kistler 2019). Whereas the decadent movement is broadly associated with the celebration of aestheticism, urban life, individual expression, strange sympathies, and provocative gender politics, its paleontological understanding was frequently connected to a diagnosis of society's ills that framed most of these associations as problems. Evolutionary thinkers regularly warned about the long-term dangers of becoming hereditarily unfit for one's environment, but theorists of directed evolution, for whom unfitness was potentially pre-programmed, had particular cause for vigilance. The most vocal called for humans to avoid the indulgent overspecialization that had apparently led animals to evolve in a spectacular but self-destructive manner, sometimes proposing eugenic solutions (Rieppel 2019: 163–65). By focusing on directed evolution, I will consider sources mostly distinct from the classic studies discussing the related literature of degeneration (Greenslade 1994), which have drawn on psychological and medical more often than on paleontological discourses. While naturalist E. Ray Lankester, in 1879, famously cited

the fall of Rome when contending that excessive comfort led to decreased anatomical complexity in sea squirts (Bowler 1989: 335–36), the bizarre fossils discoveries of the *fin de siècle* and beyond seemed to suggest that decadence was inevitable, at least for nonhuman animals. It was more often indicated by heights of complex overspecialization, evidenced in bizarre ornamentation, than it was by the degenerate neoteny of the sea squirt.

Directed evolution was theorized and explored in writings for specialists and general readerships in the anglophone sphere for over half a century. The nondisciplinary fluidity with which pronouncements on dinosaurs moved to reflections on the fall of empires makes it richly interesting for literary scholars. I will, after a brief introduction to its scientific history, focus on three representative manifestations in texts that have mostly received little critical attention. Firstly, I discuss popular romances by authors like *Weird Tales* stalwart Robert E. Howard, in which dinosaurs and decadent civilizations both act as foils to potent protagonists. Secondly, I compare H. G. Wells's *Mr. Blettsworthy on Rampole Island* and Marie Stopes's *Love's Creation*, two novels published in 1928 in which linear evolutionary cycles are implicated in contrasting social reform agendas. Finally, I demonstrate that prominent scientists used theatrical metaphors to inject tragic pathos into the otherwise pejorative characterization of phylogerontic animals. In sum, I argue that directed evolution gave a culturally recognizable shape to prehistoric and modern life alike, turning extinct animals into incarnate morals about the route to human evolutionary success. This anthropomorphism had a bracing appeal to elite and middle-class reformers who hoped that the most industrious humans could break out of the grooves condemning nonhuman animals to extinction. This optimism coexisted with unease about the ultimate failure of humanity and a sense that, in contrast with spectacular decadent genera like *Synthetoceras*, evolutionary health was mediocrity.

Senile or Decadent

Directional or cyclical interpretations of life's development have a long history, but the late nineteenth century witnessed the evolutionary formalization of these ideas, especially in Germany and the United States. To cite two crucial contributors from a wide pool of thinkers (Popov 2018: 7–28), German biologist Ernst Haeckel's epochal work on the evolutionary recapitulation performed by embryos was complemented, in the United States, by Alpheus Hyatt's research into ammonite shells, which, he contended, had evolved from a period of uncoiled youth to one of compact maturity, extinction being foreshadowed first by bizarre

ornamentation and finally by senile uncoiled forms (Allmon 2020: 441–43). “Orthogenesis” was coined in 1893 (428), as was “phylogerontic,” although the latter clinical Greek coinage was often ignored in favor of the more ominous terms “racial senescence” or “racial senility” (442). From the turn of the century on, the Yale Peabody Museum and the American Museum of Natural History in New York became centers of directed evolutionary thought. Paleontology at the Natural History Museum in London was similarly shaped by orthogeneticists like Arthur Smith Woodward, William Dickson Lang, and William Elgin Swinton.

The nineteenth-century origins of orthogenesis overlapped in some respects with theistic interpretations of life’s progressive unfolding. Evolutionary skeptics like Canadian evangelical geologist John William Dawson adopted similarly directional frameworks of rise and fall (1873: 182–83), sharing with avowedly agnostic orthogeneticists a rejection, in Bowler’s words (1989: 348), of “evolution governed by ‘chance’.” The evidence that animals could develop detrimental physical features, however, challenged paleontology’s already precarious relationship with natural theology. In the early nineteenth century, the monstrous hybridity of many extinct animals had existed in tension with Paleyan arguments for the divinely ordained functionality of their design. The South American giant ground sloth *Megatherium*, a Victorian byword for ponderous obsolescence, was characterized by Anglican paleontologists as perfectly fitted to its environment (Dawson 2011: 207). Although orthogenesis could be seen as adaptively benevolent during periods of evolutionary youth and maturity, as in the case of the horse’s fine-tuning (Osborn 1917: 267) or the mammal brain’s expansion, it left countless extinctions in its wake, including not just the ammonites and armored dinosaurs but also *Megaloceros*, another deer known for its strange antlers, and the saber-toothed cats, with canines that appeared detrimental to predation. Adaptive explanations for these dazzling structures were not widely persuasive.

This interpretation of evolution as internally and linearly directed, which appeared in many variations, was one among various competing theories, into which it occasionally bled. Thriving into the 1930s among paleontologists, directed evolution was ultimately overshadowed in anglophone science by the so-called “modern synthesis” of natural selectionism and population genetics (Cain 2013), although orthogenesis survived into the Cold War years and beyond (Popov 2018: 73–112). Robust objections to its principles were not restricted to elite channels, as indicated by a scathing letter received by London’s Natural History Museum in which Alexander Hamilton Gunner (1935), a member of the non-professional Geologists’ Association, chastised orthogeneticists for their “loose thinking,”

insisting that the “sabretooth of course *could* feed and fight” and that “each creature *succeeded* within its own time.” For the recipient, Swinton, however, directed trends caused anatomically generalized (and thus evolutionarily flexible) animals to overspecialize, growing to unsustainable sizes or developing cumbersome excrescences. At Yale, Charles Emerson Beecher (1898: 355) arranged the latter trend in a chart, mapping ontogenetic (individual) age onto phylogenetic (evolutionary) age and showing how both tended towards spinosity (*figure 2*). Paleontological writers adopted a “grotesque” mode when discussing “unwieldy” beings barely fit to live, comparing them to gothic ornamentation or the nonsensical creations of Lewis Carroll (Fallon 2021: 63–98). In one typical aside, Swinton, perhaps Britain’s most famous paleontologist in the mid-twentieth century, joked that “mighty dinosaurs” like the “grotesque” bone-headed *Pachycephalosaurus* “were a mighty nuisance to themselves” (1948: 216–17).

Half a century prior, Beecher had informed readers of the *American Journal of Science* that, just as the “decadence” of an elderly animal “produces extravagant vagaries of spines,” evolutionarily senescent lineages produce “extravagant types” (1898: 354) like the three-horned dinosaur *Triceratops*. Beecher’s evolutionary framing of inadaptable traits as “decadence” was indisputably topical. In parallel with the growth of imperialism, Western fascination with the legendary luxuriance and resultant destruction of the Roman Empire had expanded ever since the eighteenth century (Malik 2019). Uneasy reflections on the causes – or perhaps inevitability – of the falls of empires permeated nineteenth-century culture (Buckley 1967: 66–93) and Beecher’s theories were just one instance of their scientific application. The critic John Addington Symonds (1890, vol. 1: 46), for instance, drew on evolution and “organic growth” to explain the “natural end” of genres in art and literature. *Fin de siècle* aestheticism celebrated decadence’s potential for cultural transformation and disruption (Gluck 2014: 355; Denisoff 2021: 32) and many of the attributes conservative critics denounced, and aesthetes like Oscar Wilde celebrated – excess, effeminacy, delicacy, disproportion, inefficiency, ornamentation, futility – were precisely the characteristics of the “grotesque bizarrerie” (Lull 1917: 518) paleontologists mapped on to doomed extinct animals in the following decades. The 1890s decadent avant-garde did not embrace paleontological parallels, but they were exploited by reactionaries like the Marquess of Queensbury, who mockingly compared Wilde to the Cretaceous dinosaur *Iguanodon* (Greenslade 1994: 70–71).

The analogy between the declining adaptability of animal groups and the decadence of empires thrived in the twentieth century. In *The Dinosaurs* (1934), an influential text addressed to specialists and educated general readers, Swinton remarked that “senile or decadent” (181)

as the last dinosaurs were, they represented “a mighty nation whose glorious history and empire have crumbled to the dust” (208). His implication was that humans, or perhaps nations or races, ought to learn from the dinosaurs’ failure. The significance of directed evolutionary trends for human culture was explored by thinkers as divergent as Oswald Spengler (1926–28, 2: 32) and Rabindranath Tagore (1931: 28–29). As such, political interpretations were by no means uniform, beyond their yearning for grand narratives. Whereas Hyatt argued that granting women’s rights would accelerate human extinction (Bowler 1989: 341), American educator Granville Stanley Hall (1904, 2: 561) observed that it was men who were “a trifle senile, if not decadent.” In his *Glimpses of the Ages* (1905–8, vol. 1) Jamaican-born doctor Theophilus Scholes, correlating the geological “law of progression” that caused mammals to overtake reptiles (387) with a cyclical model of empires, approvingly predicted that European supremacy would be overtaken, in the “next cycle” (390), by “Ethiopic” civilization (392).

It is unsurprising that directed evolutionary theories were applied to human society, and understood in racial terms, given that “racial senescence” was usually the designation preferred over “phylogeronty.” The slippages facilitated by this terminology recall those that followed Darwin’s use of the polyvalent word “race” in *On the Origin of Species* (1859) (Beer 2009: 47). Lack of adaptive flexibility in many “extinct animals” resulted, as geologist Innokenty Pavlovich Tolmachoff speculated (1928: 1137), from “lost racial vitality.” Similarly, British eugenicists argued that white unfitness would have severe consequences for the Empire (Bland and Hall 2010: 213). Directed evolution, however, was not necessarily an attractive framework for the eugenics lobby, given the dystopian nature of a strict belief in the decline of species (Saleeby [1909]: 99–101; Bather 1920: 86). The most vocal proponents of the need to learn from directed evolution took the more optimistic view that humanity, or at least a portion of humanity, might harness it or to break away from its Calvinistic laws altogether. For the idiosyncratic orthogeneticist Henry Fairfield Osborn, doyen of the American Museum of Natural History, racial decline could be offset. The Museum’s exhibitions espoused evolutionary progress and reminded city-dwellers of the bracing physical vicissitudes of the wild; meanwhile, by promoting immigration restrictions and eugenics, Osborn and his elite clique could eliminate the unfit and non-Nordic from the American gene pool (Rieppel 2019: 144–45). Directed evolutionism was thus as often a spur to action as it was a cause for fatalism.

Close to the Primitive

Authors writing in the lost world romance genre posed their own solutions to decadence. Bradley Deane (2014) argues that “lost-world romancers” (148) like H. Rider Haggard ploughed their heroes through the wilderness so that they could harness a “primal strength” that had “eroded in the degenerate metropole” but which was still possessed by Indigenous peoples (149). This halting of decadence in the British Empire through the partial embrace of qualities deemed savage was recontextualized in the American pulps, which explored their own concerns about modern life’s enervating effects. Ferocious extinct animals came to have a dominant role in these ultra-masculine narratives on both sides of the Atlantic (Noble 2016: 54–57). Marianne Sommer (2007) even links the romances of Edgar Rice Burroughs to Osborn’s social policies: Sommer observes that, in books like *The Land That Time Forgot* (1918), the primordial lost world setting acts as an “incubator of evolution” for Burroughs’s white male protagonists (319). While these works are known for testing heroes against powerful Indigenous peoples and wild prehistoric animals, these symbols of vigor are also regularly juxtaposed with the corrupted inhabitants of decaying civilizations. This conjunction of imagery, I suggest, reflects interest not just in degeneration but also in orthogenesis. Dinosaurs, capable of representing not just natural primitiveness but also inadaptable decadence, become objective correlatives: they embody the dilemmas facing protagonists of these stories, who must always defeat both muscular monsters and morally depraved human (or humanoid) foes by drawing a balance between brute force and civilized urbane cunning. Thus, running through these stories of men taking control of the evolutionary steering wheel, we find a persistently orthogenetic aesthetic of bristling reptilian survivals and rotten, gilded citadels.

Generic conventions began to congeal following C. J. Cutcliffe Hyne’s *The Lost Continent*, an adventure set in prehistoric Atlantis and serialized in British and American editions of *Pearson’s Magazine* from 1899 to 1900. In Hyne’s story, this ancient transatlantic civilization has reached its Wildean decadence: “posturing” and “mincing” (1900: 91) Atlantean men attend only to superficialities while their ascetic priests retreat from society; all are ruled over by an evil *femme fatale* empress named Phorenice. Hyne’s Atlantis exists in at a nebulous time when giant prehistoric animals still live: Phorenice rides a mammoth, plesiosaurs haunt the waves, and dinosaurs stalk the frontiers. The protagonist, Deucalion, an official of Atlantis’s Mesoamerican provinces, is a man of simple needs repulsed by the effete Atlantean metropole. He exiles himself in disgust to the frontier, toughening himself further among “colossal lizards” like the *Brontosaurus* (274), an herbivorous dinosaur here depicted

as a predator covered, notably, in “horny plates” and “spines” (275), before returning to decadent Atlantis in an effort to reverse its decline.

Burroughs used similar ingredients. In *Tarzan the Terrible*, which appeared in *Argosy All-Story Weekly* in 1921, the lost valley of Pal-ul-don is inhabited by a predatory animal called the *gryf*, identified as a descendent of *Triceratops* by Tarzan, who has “seen its skeleton in the museum in London” (65). As Burroughs, who was familiar with teleological interpretations of evolution (Reid 2018: 216–26), likely knew, *Triceratops* was considered the last of the dinosaurs, its horned head a textbook example of how racial senescence turned useful structures into hindrances. Indeed, additional millions of years have increased the spinosity diagnosed by Beecher: the “grotesquely serrated” (10) *gryf* has “three parallel lines of bony protuberances down the back” and the blunt “hoofs” of *Triceratops* have evolved into “talons” (65–66). The bestial Tarzan, however, admires the “courage and strength” of the otherwise “[w]eird” dinosaur (66), which he uses as a steed. During the novel Tarzan encounters two kinds of racialized ape-men (both evolutionary stunted, rather than decadent, although the possibility of atavism is raised): the nature-loving black Waz-don and the white, urban Ho-don. Tarzan’s clash, significantly, is with a portion of the latter race, the effete and hypocritical priests who have corrupted the grand Ho-don city of A-lur with their cruel and extravagant rituals. Burroughs plays fast and loose with paleontological symbolism, turning a decadent dinosaur into a symbol of vigor. Nonetheless, his evolutionary intervention is clear: the *gryf*-riding Tarzan defeats the priests and reverses the decline of the debauched Ho-don metropolis through the power of evolutionary plasticity. Unlike the stagnant, habit-bound dinosaurs and apes around him, he can unsettle the linear rails that lead towards senescence.

Red Nails (1936), a story of Conan the Barbarian published in *Weird Tales* by Burroughs’s Texan contemporary Robert E. Howard, bears many similarities to Tarzan’s adventure. At the story’s commencement, Conan is attacked by a “dragon” covered in “serrated spikes,” “a monstrous survivor of an elder age” (Howard 1936a: 21–22). Conan, like Deucalion and Tarzan, is “too close to the primitive himself” not to feel some “kinship” with the ancient monster (25), and it is the combination of manly vigor, and quick thinking that allows him to poison it. This act distinguishes him from the decadent inhabitants of nearby Xuchotl, a city entirely shut off from the outside world, who believe that “no man ever killed a dragon” (Howard 1936b: 213). Locked in the city and constantly murdering each other, the inhabitants of Xuchotl are pushing themselves towards extinction. These twisted urbanites, moreover, are mere usurpers of the opulent city’s original population, an eastern race who used “necromantic

arts” to revive the “dragons ... whose monstrous bones they found in the forest.” Predictably, “luxurious sloth” rendered the original dwellers of Xuchotl easy prey to barbarian invaders, their undead saurians gradually dying of old age until Conan slays the last survivor (214). Conan, another adaptable hero capable of thwarting both destructive dinosaurs and senile urban cultures, eventually purges the debased Xuchotl of all its inhabitants. The lurid phylogerontic themes driving this story reflected subjects Howard discussed with his friend H. P. Lovecraft. Lovecraft’s letters brooded on Spengler’s diagnosis of Western “cultural senility” (Lovecraft and Howard, 1: 246) and lectured the Texan on “what Haeckel called the *first and basic law of all biogeny*,” asserting that “*the history of any life-series is repeated in the development of the individual from egg to senility*.” (Lovecraft and Howard, 2: 748).

In one more unusual novel, the role of adaptable hero was actually given to a dinosaur. Scottish-born American mathematician E. T. Bell was something of an amateur paleontologist and gave the subject a prominent place in his science fiction (Reid 1993: 12, 357), written under the name John Taine. *Before the Dawn* (1934), an early work of science fiction, depicts an invention that allows fossils to project their own life histories as three-dimensional movies. Most of the novel focuses on the lives of dinosaurs, showing Bell’s understanding of directed evolutionary processes. These are brought into relief by the projector’s capacity to speed up the fossil film, making the rise and decline of genera “no more startling or unnatural than the slow growth to maturity and the gradual decline to old age and death of a single human being” (131). The scientific spectators watch as dinosaurs’ once useful “horny armor ... continued to develop like a horrible disease,” resulting in “starving senility” (142). One observer is shocked that nature could produce such “a meaningless, helpless monstrosity” as the long-necked sauropod dinosaur dubbed the “lotus eater” (69). The novel persistently relates dinosaurs to Romantic Orientalist images of luxury and despotism, giving specimens biblical names like Belshazzar, Satan, and Jezebel that suggest the orgiastic paintings of John Martin.

In a surprising twist, the tyrannosaur Belshazzar, like the hero of a pulp romance, begins to transcend this decadent environment. Predatory dinosaurs were not usually understood as having evolved in the phylogerontic direction ascribed to herbivores like the sauropods, ceratopsians, and stegosaurs, giving them a somewhat ambivalent symbolism in the directed evolutionary narrative. This ambivalence likely contributed to the fact that the vigorous and thus faintly admirable dinosaurs in the lost world romances I have discussed were all predatory (even if, in the case of Hyne’s *Brontosaurus* and Burroughs’s *Triceratops*, this meant rejecting commonplace scientific knowledge). Bell’s narrator recognizes the predatory “bipedal lizards”

as a “great race” and “one of nature’s major efforts” (120–21). Belshazzar himself is “a perfectly balanced engine of aggressive destruction” (160), words echoing Osborn’s (1917: 214) memorable description of *Tyrannosaurus rex* as “the most destructive life engine which has ever evolved.” Belshazzar attracts the awe and sympathy of onlookers not simply for his physical power; he is depicted as one of “the pioneers of science,” his survival techniques displaying knowledge of “the laws of levers,” the “law of falling bodies,” and the principles of “hydrostatics” (219–21). When he is killed in an epic confrontation, the novel ends with Belshazzar’s “last snarl of defiance” (247). In all these stories, it is the ability to master one’s shifting environments that makes for a laudable protagonist, combining brains and brawn to reject seemingly inexorable processes of emasculation and extinction.

Survival of the Rotten

The directed evolutionary ethics loosely dramatized in pulp romance and science fiction could be laid out more prescriptively in novels of ideas like *Love’s Creation* (1928), penned by Marie Stopes. Although, by the time of the novel’s publication, Stopes was best known as a birth control campaigner, her previous career had been that of a professional paleobotanist, employed at the University of Manchester from 1904 to 1910. Stopes was versed in the various evolutionary mechanisms then in circulation and may well have discussed them with D. M. S. Watson, a student with whom she produced an influential paper on coal (Chaloner 2005: 132), and who went on persuasively to argue for evidence of orthogenesis in amphibians (Bowler 1996: 238–39). Carla Hustak (2014) has pointed out some continuities between Stopes’s paleobotanical and sexological thought, but *Love’s Creation* contains one of her frankest applications of paleontological research to twentieth-century social life.

Stopes’s 1928 novel concerns a central romantic pair, University of London biologist Kenneth Harvey and genteel idealist Amber Rose. The thorny path to their marriage explores various approaches to convention, love, and sex. While Rose ruminates on “a general theory” to solve the “problem” of “human life and love” (71–72), Kenneth decides that his biology lacks paleontological perspective. After his first wife dies, Kenneth becomes a wanderer in South and Southeast Asia, where his initial racist revulsion at Asian populations spurs him to search for the “bridge” (227) linking him with the Other, turning to Buddhist and Daoist texts for insights about the individual’s relation to the whole as well as studying more paleontology in the United States (302–3). Finally, his “big illuminating idea” (264) is explained at length

in a chapter paratextually prefaced with the forbidding warning that it “should only be read by those who *think*” (317). Kenneth has been persuaded by “the bigger Palaeontologists, like Osborne [*sic*] and Smith Woodward” that, contra the belief that natural selection promotes superiority, animal groups “die out automatically,” each “*following a definite course of procedure more or less regardless of their environment*” (325–27). Kenneth believes that his variant of orthogenesis will be paradigm-shattering: individual lives, he argues, are mere components of a “larger unit,” much as “individual cells composing our brains” produce “a super-something – a *consciousness*” (328–29). Amber Rose listens to his unfolding exposition with quasi-sexual excitement: “‘Yes, yes,’ she breathed, enthralled” (329). Kenneth compares the way extinct animals within this larger unit are “jerked off the rails” to the metamorphosis of a “caterpillar” (330). Phylogeronty and extinction represent the aggregate consciousness sloughing off elements not needed for a higher evolution.

In the words of her biographer (Rose 1992: 134), Stopes “was an élitist, an idealist, interested in creating a society in which only the best and the beautiful should survive.” There was thus a “strong eugenic strain in her views,” albeit one of a rather “maverick” character (Bland and Hall 2010: 217). As suggested by Stopes’s authorial address to “those who *think*”, her eugenic elitism manifests in Kenneth’s theory’s. Kenneth argues that “diseased city dwellers” should be thought of not as “isolated strains doomed to individual extinction” but as “festerings sores” in the “Greater Consciousness” (340–41). It is “*our* responsibility,” he adds, to “destroy the diseased fragments” (341–42). His terminology characterizes dysgenic individuals less as sores in need of healing than as infected dirt within these sores. Like Osborn, whose work we have seen Kenneth approvingly cite, Stopes’s author-surrogate here suggests that, using eugenic methods, the orthogenetic cycles of evolution can be harnessed for the health of the human species, or, more probably, given the tenor of Stopes’s pronouncements (Rose 1992: 147, 155), the white middle-class members of the species. In addition to the negative eugenics Kenneth more or less proposes, positive eugenic evolution is practiced by the protagonists: after the death of his first wife, Kenneth’s mother laments “that her son’s life would no longer develop along the lines she anticipated” (182), but his more sexually compatible marriage with Rose reveals that this initial derailing, to mix metaphors, has released both lovers from their “chrysalis” (412).

Love’s Creation can profitably be contrasted with another novel published in 1928, H. G. Wells’s *Mr. Blettsworthy on Rampole Island*. The Gulliver-like protagonist of this satirical work is stranded on an island of cannibals. The humans on the island are terrorized by

villainous specimens of the prehistoric ground sloth *Megatherium*, “grotesque monsters” (142) who survive by obstructing the progress of other lifeforms. Directed evolution, I contend, plays a thematic role in the novel, notwithstanding the fact that Wells was no committed orthogeneticist. He had adopted a chiefly Darwinian framework in his first evolutionary epic serial, *The Outline of History* (1919–1920), and *The Science of Life* (1931 [1929–30]), a later part-work co-authored by Wells, his son, and biologist Julian Huxley, threw “the shadow of doubt” upon directed evolution in favor of selectionist arguments (350). As for “racial senescence,” the authors considered it a “loose” analogy, themselves attributing extinction not to “inner ageing of the germ-plasm” but to “changes in outer conditions” disadvantageous to species that had “moulded themselves too perfectly to the passing world” (382–83). Despite the skepticism in *The Science of Life*, written alongside *Blettsworthy*, at least one author found Wells’s novel representative of directed evolutionary thought. In *The Dinosaur in East Africa* (1930), geologist John Parkinson drew his epigraph from Blettsworthy’s observation on the *Megatherium*: “far from Evolution being necessarily a strenuous upward progress to more life and yet more life, it might become, it could and did evidently in this case become, a graceless drift towards a dead end” (Wells 1928: 171–72). This epigraph from *Blettsworthy*, Parkinson implied, epitomized his own book’s view of the dinosaurs’ “degenerate senility” (173).

As Parkinson sensed, phylogeronty is rife in Wells’s novel. Observing Rampole Island’s repulsive ground sloths, Blettsworthy, once the complacent heir to an ancient Wiltshire family, must reassess his faith in progress. Whereas he previously believed that a species facing changed conditions “produced an adaptation to fit it beautifully to these new conditions,” the senescence of the *Megatherium* suggests, instead, that “species under altered conditions did the queerest and most futile things” (170). Blettsworthy concludes that “animals do not necessarily survive by being swifter, stronger or wiser” and that the “survival of the rotten and dying is possible” (171). The choice of *Megatherium* was pointed. Wells likely knew that the extinction of this animal was not conventionally attributed to phylogerontic maladaptation. Rather, he was sarcastically bringing into a twentieth-century context the nineteenth-century natural-theological arguments I mentioned above, in which *Megatherium* exemplified how a superficially monstrous animal was perfectly fitted for survival. Wells’s assault on theistic Victorian science was underlined by the novel’s early scenes, in which Blettsworthy is influenced by his naïve uncle, a fusion of Pangloss and Charles Kingsley, who repeats that “all things work together for good” (32). Indeed, by the early twentieth century, mid-Victorian thinkers were coming to be seen as “Megatheria” themselves (Smith 1918: 230).

Defunct Victorian science was not Wells's primary target, however. Later in the novel, Wells reveals that Blettsworthy's adventures on Rampole Island were a trauma-induced hallucination: the *Megatherium* were his mind's symbolic representation of the failing liberal institutions of Western Europe. Blettsworthy regains full consciousness during the Great War, the catastrophic product of these failures. The novel's quasi-allegorical form was, presumably, an example of the superior "technique" for a "novel of ideas" Wells alluded to when he chastised Stopes for the metaleptic framing of her chapter on orthogenesis (Rose 1992: 189). Wells, unlike Stopes, wished to avoid breaking the reader's suspension of disbelief. The moral of his novel emerges gradually: even before his awakening, in Blettsworthy's mind "Institutions had become entirely confused with Megatheria and Megatheria with Institutions" (174). Blettsworthy accepts the "analogy" that the "institutions of mankind came just as much within the scope of biological generalization as the life of any other living being": thus, just as Rampole's *Megatherium* obstruct youthful species, "obstinate obstructives" linger in human society (172–72). After the War, a despondent Blettsworthy is invited to the National Liberal Club by Lyulph Graves, an old acquaintance who once betrayed Blettsworthy's trust but who has now also been chastened by society's inadequacies. Like the socialist Wells himself (Toye 2008: 184), Graves retains faith in aspects of liberalism, but he argues that the megatherial Liberal Club represents "a banner of progress that someone has forgotten to carry on" since its "Gladstonian" glory days in the nineteenth century (279). These outmoded Victorian organizations, however, "can be changed without any change of nature" (287). By maximizing the "efficiency of the educational machinery of mankind," Graves contends, "Megatheria *can* die" (285). Political rationalization is possible, but not without serious educational reform.

The novel's skepticism about the inevitability of evolutionary and political progress reflected a career spent defusing complacent views like those initially held by Blettsworthy and his uncle. Adam Roberts (2019: 347) notes *Blettsworthy's* position in a "feedback loop" running back to Wells's rejection of evolutionary optimism in *The Time Machine* (1895), which, Bowler (1989: 337) observes, pointedly depicts evolution as non-directed: the murderous Morlocks and feeble Eloi of the far future represent degenerate adaptations by different social classes of humans to their environments. Wells's contemporaneous journalism rejected the "clamour for the Systematic Massacre of the Unfit" and insisted on the all-importance of education to avoid a decadent future (1896: 595). Although he consistently prioritized education, as shown by *Blettsworthy*, the technocratic Wells, like Stopes, also came to endorse negative eugenic policies, particularly regarding the suppression of certain mental

illnesses and disabilities (Stover 1990). Unlike Stopes, however, he saw eugenics as a less reliable tool for creating an ideal society than socialist mass education (Partington 2003: 77).

Using the “old-young Megatherium” in *Blettsworthy* (279), Wells suggested that elements of directed evolution might be valid not, perhaps, in the natural world, but instead in the political world. Surviving at the end of their life cycle despite being neither fit nor willing to breed, the sloth-institutions comically defy selectionism. Most proponents of orthogenesis suggested that phylogerontic genera faced extinction when ecological conditions changed; under amenable conditions, even overspecialized dinosaurs like *Triceratops* might endure. The *Megatherium* of Rampole Island achieve endless old age by preventing changes, parodically contravening Wells’s precept, noted by Simon J. James (2012: 126–27), that static societies face “extinction.” By stressing that the senile *Megatherium* represent political institutions, Wells denaturalizes the evolutionary logic of his story. Whereas *Love’s Creation* recommends that society lean into the inevitable direction of evolution by pruning phylogerontic individuals, *Blettsworthy* preaches amelioration by changing the environment, using left-wing educational reforms to eliminate senescent political structures. Throughout the novel, as Blettsworthy becomes disillusioned with the liberal assumptions of his youth, he feels that his body, in phylogerontic manner, is “in hideous discord with the entirely inhospitable world into which it had come” (88). The problem is with unreformed Victorian social structures, rather than with Blettsworthy. For Graves, rather than forcing the inadequate individual to fit the environment or die, the inadequate environment may be adapted for the good of the individual. Whether we are intended to agree with a character who once swindled Blettsworthy out of his money and slept with his girlfriend is debatable, but Wells gives us little alternative.

During the Second World War, his interbellum hopes for educational meliorism thwarted, an embittered Wells returned to directed evolutionary language. In his *Nature* article “The Illusion of Personality” (1944: 395), Wells was no longer dismissive of phylogeronty, citing “repeated” paleontological precedent for the emergence of a “flurry of abnormalities before the collapse and obliteration of some dominant group which has outstayed its welcome.” Now he judged that the same phylogerontic pathology that produced “abnormalities” in extinct genera “seems to be the case with man to-day” (395), given that “man” offers “no collective resistance in the face of change” and “persists in his follies” (397). This time, the extent to which Wells was speaking in dark analogy was left unclear.

Fragments of Old Play-Bills

For Blettsworthy's friend, the megatherial vestiges of Victorian liberalism do not "know how to get off the stage" (279). The notion of prehistory, and, indeed, history, as a stage, was a venerable one (O'Connor 2007: 377–84). Animal groups and geological eras, much like individual lives and civilizations, were framed as reaching a "climax" followed by denouement and curtain (Osborn 1917: 183, 210, 225). Shakespeare allusions, especially evolutionary spins on Jaques's monologue about the seven ages of man in *As You Like It* (Hutchinson 1889: 260–61), came instinctively to the pens of British paleontologists (Parkinson 1930: 56, 91, 103). "Shakespeare has made us familiar with human growth-stages," casually noted William Dickson Lang in a paper on Old Age and Extinction in Fossils" (1919: 102). Observing that "an eventful history" would postpone an evolutionary "second childhood," Francis Arthur Bather (1928: lxxxiv), Keeper of Geology at the Natural History Museum, was similarly offering a Jaques-inflected view of evolution. Shakespeare allusions are, of course, ubiquitous in modern British writing, but their persistent association with directed evolutionism merits further attention. These writers, it seems, found in Shakespearean tragedy and stage metaphors the same tensions between inevitable decline and individual agency contained in directed evolutionism. Audiences can identify Macbeth's *hamartia*, but they cannot prevent his fall. Harmful orthogenetic trends can be identified, but can they be halted?

Viewing directed evolution through a Shakespearean lens was natural for Bather, author of scholarly works discussing "the Physiology, Morphology, and Embryology" of "The Puns of Shakespeare" (1887: 83) and scrutinizing *The State of Hamlet's Mind* (1926). Having contributed to orthogenetic vocabulary at the *fin de siècle*, by the 1920s Bather was experiencing doubts. He warned the British Association that, while the idea that genera let out a "despairing outburst before death" was "delightful as metaphor," it likely stemmed from "ignorance alone" (1920: 85). These doubts did not always temper his sense that extinction was as gloomily preordained as the climax of a Shakespearean tragedy. In the peroration of a 1928 address to the Geological Society, Bather reflected that countless "Classes and Orders" had finally lost the "flexibility ... with which to meet new conditions" (xcvi), putting on "a short-lived majesty" and fading before even learning "to wield the sceptre and to support the crown." Bringing humanity into this narrative, Bather imagined an Anthropocene wasteland of the future in which "Man" is forced, "more literally than Hamlet, to 'feed on air,'" as the human races decline towards "the inexorable end." With these words he launched into Hotspur's dying lines in *Henry IV, Part 1*:

But Thought's the slave of Life, and Life, Time's fool;
And Time, that takes survey of all the world,
Must have a stop. (xcvii)

Bather, a specialized invertebrate paleontologist, wryly observed that he was aptly ceding his presidential title to an “unspecialized” geological generalist, J. W. Gregory (xcvii). Inelastic species, kings, and presidents of the Geological Society alike faced inevitable obsolescence.

Bather's histrionics reflected a more empathetic approach towards these foredoomed animals than we have usually seen. If humans, too, were incapable of escaping evolution's cyclicity, even a dinosaur might generate pathos. In Bell's *Before the Dawn*, the projected scenes of prehistory are persistently framed as a “a cosmic tragedy” (1934: 19) or “comedy” (85) in which, as we have seen, the tyrannosaur is the “hero” (25). In the projection theater humans walk “upon the stage, but as spectators, not actors,” passing through the dinosaurs “as if they were air” (23). The “dreamlike” (39) nature of these projections recalls Prospero's fairy masque in *The Tempest*, which melts “into thin air” like life itself, “such stuff / As dreams are made on” (Shakespeare 2011: 4.1.150, 156–57). Visual access to Mesozoic life prompts sober reflection. A technician notes that humanity will one day be just another recorded “spectacle” for unsympathetic future beings (24). Another proposes that “our overdeveloped central nervous system” is “as outdated as the over-protected, over-armored monstrosities we saw in some of the later records” – although he also speculates, in a more Stopesean mood, that human “psychic development” may be able to “subdue nature.” (139). Jacquetta Hawkes, too, wondered if the gigantism of the human brain was any less evolutionarily misguided than “the horn of *Synthetoceras*” (1951: 35). If not, the specialized development of useless “protuberances” could be seen as a group's last “heroic efforts” or an “inner deficiency” that nonetheless resulted in “high perfection in certain features” (Tolmachoff 1928: 1133, 1140). Noting the “moral preoccupations” that led scientists to promote one evolutionary mechanism over another, the co-authors of *The Science of Life* found “something heroic in the obstinate advance of Orthogenesis” (Wells, Wells, and Huxley 1931: 265). Rather than imperial Roman languor, this was a dignified fall caused by tragic *hamartia*.

These animals faced what Swinton called “the problem of Hamlet”: “[t]o be or not to be”—specialized” (1948: 219). We have already heard some of Swinton's normative pronouncements on the “old and effete” genera described in *The Dinosaurs* (1934: 179), but the book's elegiac conclusion strayed beyond his characteristic grotesque register. The dinosaurs' “drama,” he declared, “was a well-acted one and had an exceptionally long run,” tempting Swinton “to anthropomorphize” and wonder if these animals believed themselves

“the emperors for all time” (208). He characterized the fossil record as a theatre pasted with “the fragments of old play-bills,” leaving readers to ponder “what lesson there is” in the final “failure,” despite a “long run,” of the dinosaurs’ great drama (209). Elsewhere, Swinton was more explicit about what the box office decline of spectacular genera meant. In *Giants Past and Present* (1966), he gloomily predicted that, in the future, “the incurable inhumanity of man to man will have erased the weak.” Rather than framing this as a victorious elimination of the unfit in the style of *Love’s Creation*, however, he saw it as a sad victory of “*Demos*, the god of mediocrity.” Based on the paleontological evidence that “it was never the brilliant, the exotic, the spectacular that survived,” but rather “the mediocre,” he predicted that the future belonged to “[s]mall men” (183). For all his mockery of spinescent genera, then, Swinton suspected that long-term evolutionary victory required bland mediocrity.

Although dinosaurs were by then on the verge of a dramatic reinterpretation (Ostrom 1969), Swinton’s revised 1970 edition of *The Dinosaurs* differed relatively little from its 1934 original. His overall estimation of the dinosaurs, indicated by an epigraph in heroic couplets, was more negative than ever:

They built no cities, shaped no great empires
 Knew naught of wisdom, had but few desires.
 They lived each day as life itself compelled,
 Marked no tomorrow for all it might have held.
 Friendless in life and all alone in death
 They left but dust—yet men have given it breath. (Swinton 1970: n.p.)

Nonetheless, Swinton, by this point working at the Royal Ontario Museum and the University of Toronto, tacitly admitted to the marginalization of directed evolutionism in the postwar decades, inserting qualifications to several orthogenetic claims (*figure 3*). Far wider audiences would still have been reading his more affordable and near-identically titled *Dinosaurs* (1962), which cast no doubt on “phylogeronty, the old age of a phylum” (36). As Swinton was informed in 1977, a barely altered edition of the 1962 *Dinosaurs* was still selling well in the London Natural History Museum’s bookshop (Cross 1977).

Meanwhile, paleontologist Stephen Jay Gould (1973: 16) was informing general readers of *Natural History*, the popular magazine of the American Museum of Natural History, that the case for orthogenesis had “never rested on more than subjective wonderment.” By this point, even the Fall of Rome was being reconsidered by historians as no fall at all (Bowersock 1996: 35; Malik 2019: 43). The concept of decadence itself had become deeply unfashionable among professional historians: as Harry Ritter’s *Dictionary of Concepts in History* (1986)

stated, theories of decadence were lately deemed overly “value-laden (99) while “the analogy of the natural life cycle as a guide for scholarship is widely mistrusted” (102). More recently, Neville Morley (2004: 575) attributed the decline of decadence to its “too obviously literary” nature, hinting, however, that its unpopularity among historians stemmed less from conceptual rejection than from its status as an insufficiently “dead” metaphor.

In William Hope Hodgson’s apocalyptic romance *The Night Land* (1912), evolution comes full circle. In the far future, at a time when humans struggle to survive after the death of the sun, “olden Monsters” resembling those that existed “in the Early World” are “bred in the Ending” (129). For Hodgson, dinosaurs and other prehistoric creatures inevitably return when we approach the end – shadows cast by our own decadence. Whether in the hands of popular romancers, didactic reformers, or paleontologists, directed evolution was a potent source of imaginative and political inspiration between the nineteenth-century *fin de siècle* and the postwar decades. Gould’s accusation that this school of thought was grounded on “subjective wonderment” benefited from hindsight; nonetheless, its burgeoning at the height of imperialism, and of both the decadent and the eugenic movements, was reflected by the analogical language with which it was discussed, as well as by proponents’ eagerness to move seamlessly between evolutionary concepts and social diagnoses. The moralization of orthogenesis and phylogeronty was far from internally consistent, especially given the tension between those who saw humans as able to combat the process and those pessimists who rejected this notion. Directed evolution thus attracted diverse political constituencies, although, in many of the sources I selected, we have repeatedly seen it tied to conservative anxieties about masculine virility as well as racial and class hygiene.

Running through many of these discussions was the fear that overspecialization created weak, alienated individuals and societies. Overspecialization, in addition to signifying harmfully rigid evolutionary trends, could also mean the extreme subdivision of labor or of scholarly disciplinarity, and indeed often dimly included all three. The likes of Osborn and Burroughs preached the value of a strenuous life and varied interests as the way to avoid becoming the human equivalent of a specialized, spinescent *Triceratops*. A very different thinker, Virginia Woolf, also looked to prehistory to challenge the constrictive structures of modern society. Evelyn Tsz Yan Chan argues (2014: 154) that Woolf infused her country-house novel *Between the Acts* (1941) with imagery of anatomically generalized prehistoric animals, enacting a devolutionary “retreat from overspecialization” to help “reach a balance in

modern life” (154). Orthogeneticists, of course, would have warned that prehistory contains countless precedents for overspecialization as well, but Woolf, a reader of Wells serials like *The Science of Life*, had little time for teleological interpretations of life’s development. Catriona Livingstone (2022: 195) adds that in *Between the Acts* and other late Woolf novels, “sympathetic identification with other members of the community,” including animals, “causes characters to become aware of and identify with unrealized aspects of their selves,” questioning the social and evolutionary grooves down which they are being unconsciously driven. Woolf avoided structuring evolution and social history as a deterministic series of rises and declines, instead asserting the emancipatory potential of overlaps and unexpected affinities.

In contrast with Woolf’s modernistic vision, directed evolution’s appeal was that it offered a linear but resonant narrative structure applicable to the prehistoric, ancient, and modern worlds alike – decadence – along with a new opportunity to take charge of historical progress. Its potential fatalism generated the contradictions that I have highlighted: authors looked upon phylogerontic animals mostly with scorn, but sometimes with empathy and awe. These animals were repeatedly cited as evidence in favor of prioritizing flexibility over habit, brains over brawn – but not without the sense that something important and even wonderful was being lost along the way. Even before paleontologists began more regularly to consider structures attributed to orthogenesis as adaptive products of natural and sexual selection, these reflections were sobering. They hinted that decadence might merit praise and preservation, implying criteria of value in the struggle for life distinct from resilience, moderation, and even intelligence. In this light, the forked horn of *Synthetoceras*, did not look quite so ridiculous.

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Figures

Figure 1. Restoration of the extinct deer *Synthetoceras* by Erna Pinner, in William Elgin Swinton's *The Corridor of Life* (1948: 220). Pinner's vivid illustration, and Swinton's accompanying text, were likely the inspiration for Jacquetta Hawkes's selection of this obscure genus as her example of the perils of directed evolution. Reproduced with the kind permission of Frances Kitson, Jacky Oldham, and Peter Oldham.

Figure 2. A diagrammatic demonstration of the analogy between spiny skin on an elderly individual animal and in an evolutionary elderly species, in Charles Emerson Beecher's "The Origin and Significance of Spines" (1898: 355). Reproduced courtesy of the Cadbury Research Library, University of Birmingham.

Figure 1. William Elgin Swinton inserts qualifications to his earlier comments on the "decadent" status of the later dinosaurs in the 1970 revision of his 1934 work, *The Dinosaurs*. SC95 William Elgin Swinton Fonds, Box 2, Folder 3 (Edited Manuscript of *The Dinosaurs*). Courtesy of the Royal Ontario Museum.



Fig. 83 SYNTHETOCERAS
A ruminant with unusual horns

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generic, and sometimes of family rank, or even higher. They have therefore acquired a fixed importance in these special groups, and are recognized in the same categories with physiological and structural characters. The differences which appear at an early period in higher genera are the bases of distinction among lower genera. If the spines or other similar features do not make their appearance in an individual until a late adolescent stage, they are usually of negative value in a scheme of classification. This agrees with the general principle recently suggested by Harris,²² that when the main features of the ornament (= spines, etc.) are foreshadowed in the larval and early adolescent stages, they are to be regarded as of taxonomic value.



	Ontogeny stages.	Ontogeny condition.	Phylogeny stages.	Phylogeny condition.	Chronology.
	Old age or gerontic	Paraplasis	Phylogerontic	Paracme	5
	Adult or ephebic	Metaplasis	Phylephebic	Acme	4
	Immature or neanic	Anaplasis	Phyloneanic	Epacme	3
	Larval or nepionic	Anaplasis	Phylonepionic	Epacme	2
	Embryonic	Anaplasis	Phylembryonic	Epacme	1

Diagram and table showing correlation of stages and conditions of development in the spinose individual, in its ancestry, and in time.

The preceding diagram illustrates the previous statements, and shows the correlation between the stages and conditions of growth in the ontogeny of a spinose individual, with its phylogeny, and also the chronology of groups containing spinose

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habitat. Amongst senile forms toothlessness is common, not only individual toothlessness, but a tendency for whole families to become thus handicapped. This tendency has been observed and described by Sir A. Smith Woodward in a Theropod dinosaur, *Genyodectes*, from the Upper Cretaceous of Patagonia, while we have described ~~other~~ ^{the toothless} examples in the previous pages. Yet, senile or decadent as these forms ~~were~~, there is little indication that they could not have carried on for a considerably longer period, and there seems no doubt that although this racial senility was a predisposing factor towards extinction, it was not in itself sufficient cause.

one alleged
to have been

Ornithomimus

So-called