MEDICINA NEI SECOLI ARTE E SCIENZA, 26/1 (2014) 197-222
Journal of History of Medicine

Articoli/*Articles*

RETROGRESSIVE DEVELOPMENT: TRANSCENDENTAL ANATOMY AND TERATOLOGY IN NINETEENTH-CENTURY BRITAIN

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SUMMARY

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In 1855 the leading British transcendental anatomist Robert Knox proposed a theory of retrogressive development according to which the human embryo could give rise to ancestral types or races and the animal embryo to other species within the same family. Unlike monsters attributed to the older theory of arrested development, new forms produced by retrogression were neither imperfect nor equivalent to a stage in the embryo's development. Instead, Knox postulated that embryos contained all possible specific forms in potentia. Retrogressive development could account for examples of atavism or racial throwbacks, and formed part of Knox's theory of rapid (saltatory) species change. Knox's evolutionary theorizing was soon eclipsed by the better presented and more socially acceptable Darwinian gradualism, but the concept of retrogressive development remained influential in anthropology and the social sciences, and Knox's work can be seen as the scientific basis for theories of physical, mental and cultural degeneracy.

Key words: Transcendentalism – Embryology – Evolution – Robert Knox

Introduction

Recapitulation and Teratogenesis

The revolutionary fervor of late-eighteenth century Europe prompted a surge of interest in anatomy as a process rather than as a description of static nature. In embryology, preformation – the theory that the fully formed animal exists in miniature in the earliest germ – was largely discarded in favour of epigenesis: embryonic development through successive formation of parts that were not preexistent. At the same time, the *scala naturae*, the morphological consecution of all living things known as the great "chain of being", came to look less like a chain and more like a ladder of progress[1]. Apparent structural correspondences between the hierarchical scale of life and the developing embryo led to their being conceptually linked through what would come to be known as the theory of recapitulation.

Variously called embryological parallelism, the Meckel-Serres law, or the biogenetic law, recapitulation theory is often summarised by the axiom "ontogeny recapitulates phylogeny", a formula devised by the zoologist and Darwinist Ernst Haeckel (1834-1919) who, in his endeavors to explain the mechanics of embryogenesis and to overcome objections that epigenesis lacked an evident driving force, proposed phylogeny (the historical development of the species) as the mechanical cause of ontogeny (the development of the individual organism)[2]. Though recapitulation became associated with species change, the earliest formal statements of the theory were made by German philosophical naturalists in the 1790s, before the development of theories of progressive organic evolution, and were based on the classical model of a fixed *scala naturae*, a graded series of creatures of increasing complexity from monad (the simplest of animals) to man[3]. Recapitulation appeared to explain the many apparent similarities between embryonic forms and mature animals of different species, one of the best-known of which, the resemblance between

the transient branchial arches of the human embryo and the gills of a fish, was popularized by the often repeated claim that the human embryo passes through a "fish-like" stage (Fig. 1).

Indirect support for recapitulation came from early modern readings of malformed human foetuses – in pre-nineteenth century terminology, "monstrous births" – which were commonly interpreted in terms of their resemblance to non-human animals[4]. Although descriptions of human offspring as animal-like were not linked with any particular theory of teratogenesis, they did imply that the human foetus might develop into a non-human animal if normal processes were perturbed. Prior to the nineteenth century, aetiologies of monstrous births had to account for animal births to human mothers, of which there were

Fig. 1 - Plate showing embryos of fish (F), salamander (A), turtle (T), chick (H), pig (S), cow (R), rabbit (K), and human (M), at "very early", "somewhat later" and "still later" stages. Similarities between species were presented as evidence of recapitulation of adult forms during development. From Ernst Haeckel's *Anthropogenie* (1874).

many reports in Western European literature, and which were widely credited as a possibility until the eighteenth century[5]. These animal-like progeny were often attributed to "maternal impressions", the venerable theory that an as yet unformed foetus could acquire the appearance of an object or person seen by the mother at conception or during early pregnancy, and there were many tales of such monsters born to women who had been frightened by animals[6]. By the nineteenth century, the theory of maternal impressions had fallen from favour, largely for want of a plausible mechanism, coherent with contemporary anatomical knowledge, by which the maternal psyche could connect with the developing embryo. Nevertheless, medical accounts of human foetuses that resembled animals continued to appear in learned journals and their authors still sometimes invoked maternal impressions, albeit with a degree of scepticism, as a potential cause[7].
An alternative theory, proposed by Fortunio Liceti in his great work *De Monstrorum* (1634) was one of degeneration, according to which human seed that was somehow vitiated or deprived of its generative potency could engender non-human offspring[8]. While Liceti's theory of seminal degeneration did not presuppose epigenesis (Aristotelian coalescence of the foetus from semen and menstrual blood was his preferred model) it did suggest that, since animal forms arose when human development was perturbed, the generative property of animal and human semen was quantitatively rather than qualitatively different. Thus it was supposed that corrupt uterine humours could breed "false conceptions": strange rat-like animals that were quickened "against nature" from defective semen[9].
Recapitulation theory supported a view of animals as imperfect humans and, by linking phylogeny and embryogenesis, observers reinterpreted animal-like conceptuses born to human mothers as arrests of development. Etienne Serres (1789-1868) drew on his experience of having dissected malformed foetuses and on Etienne Geoffroy Saint Hilaire's (1772-1844) work on teratology to explain various

congenital malformations in terms of arrest or overdevelopment of the foetus[10]. The apparent facility with which the theory of arrested development could account for known types of birth defects was a point in its favour when transcendental anatomists introduced it into Britain from the Continent in the 1830s. The conceptual framework of recapitulation encouraged continued emphasis on similarities between human birth defects and "lower" animals in the anatomical literature. To understand why "arrested development" was soon superseded by the apparently self-contradictory concept of "retrogressive development", we must consider the wider implications of the transcendentalists' ambitious intellectual programme.

British Transcendentalism

The two eponymous authors of the biogenetic law, Etienne Serres and Johann Friedrich Meckel (1781-1833), both based their researches on the new transcendental approach to anatomy that sprang up in Germany and France in the early decades of the nineteenth century. Transcendental anatomy, also known as "philosophical" or "higher" anatomy, is difficult to define succinctly, but a useful summary of its theoretical underpinnings is Rehbock's tetrad of (a) an ideal body plan, (b) which acts as a force for maintenance of anatomical uniformity, (c) which exists *a priori* but not in nature, (d) and which can be studied to reveal "laws" of development[11]. Philosophical transcendentalism, which took its inspiration from the work of Kant, had a wide-ranging influence on theologians and writers, giving rise to a movement in New England that flourished in the 1830s and 1840s and inspiring English romantics such as Samuel Taylor Coleridge and Percy Shelley[12]. Transcendental biology is usually dated to the 1780s when Goethe endeavored to deduce *Urpflanze* and *Urtier* – ideal archetypes for plants and animals – from observations of nature[13]. With its emphasis on the schematization of pattern and its assumption that the structure of the part reflects that of the whole,

transcendentalism can be located within the tradition of macrocosm and microcosm, a revival of the quest for structural and metaphysical correspondences between the human body and the cosmos. The transcendental vision of the vertebra as "the type of all vertebrate animals, of the entire skeleton ... of the organic world ... [which] possesses the form of the primitive cell; of the sphere; of the universe"[14] bears comparison with the physician and alchemist Robert Fludd's reading of the human body as a microcosm or miniature pattern of all the parts of the universe[15], and some have categorized transcendentalism a quasi-mystical system[16].

Goethe's application of transcendental ideas to biology proved fruitful, opening the way for theories of development and evolution that broke down Kant's epistemic barrier between the empirical study and classification of animals and plants as they presently were and a historical science of nature that described changes over time[17]. Medical practitioners and anatomists in early-nineteenth century France and Britain applied transcendental principles to observational data in a programme of study that it was hoped would establish fundamental "laws" – a concept hitherto associated with the inorganic sciences – that could combine comparative anatomy, embryology and the history of species within an all-inclusive explanatory schema[18].

The introduction of transcendentalism to Britain in the 1830s supplied a conceptual framework that revitalized the teaching of anatomy. Though initially perceived as ridiculous, transcendental anatomy soon became so widely accepted that it was known as "the doctrine", and it seemed that "everybody", at least in the medical schools, embraced it[19]. Ambitious anatomists saw an opportunity to make a name for themselves, and the more complacent came under pressure from students to teach the new anatomy, which was perceived as radical since its emphasis on structural interrelationships between species encouraged speculation on their historical development, a notion that, given its

French republican associations, seemed truly revolutionary. In London, Professor Granville Sharp Pattison's (1791–1851) students rioted in protest at his "total ignorance of and disgusting indifference to new anatomical views and researches". It paid to teach radical anatomy[20].

Arrested Development

Nineteenth-century teratologists contributed to the transcendentalists' pursuit of anatomy's general laws by describing and classifying examples of monstrous births as though they were representatives of distinct groups or species. Isidore Geoffroy Saint Hilaire's (1805-61) extensive *Histoire générale et particulière des anomalies de l'organisation chez l'homme et les animaux* (1832-7) was, in essence, a taxonomy of monsters[21]. The theory of arrested development – both Geoffroy and Meckel described it as a law[22] – was predicated on parallelism between embryological development and a linear taxonomy of adult organisms: monsters resembled the adult forms of lower species. According to Geoffroy, monsters caused by arrest of development were "des embryons permanens"[23], and the Parisian surgeon-anatomist Philippe-Frédéric Blandin (1798-1849) attributed human monstrosities to arrests of development at one of the progressive stages through which the human embryo passes: the least recognizably human monsters were due to arrests earliest in development[24]. In Britain, the term "arrested development" was first used in print in 1830 in the *Lancet*, in a review of Meckel's work, and was adopted by the comparative anatomist Richard Owen (1804-92) as early as 1835[25]. The concept spread into mainstream medical writing and became a standard explanation in case reports of human monstrosities[26]. It also achieved swift public acceptance through such popular works as the 1839 *Penny Cyclopaedia*[27].

The favourable reception of arrested development was largely due to its ability to supply an aetiology for congenital malformations, in which respect it was seen as having filled the "great blank"[28] left by the

demise of the time-honoured theory of maternal impressions, which had become scientifically untenable as there seemed to be no plausible route through which maternal visual stimuli might be transmitted to the foetus in order to generate "impressions"[29]. Instead, medical men looked to philosophical anatomy to provide a better understanding of the pathogenesis of monstrosities. According to John North (1790-1873), one of London's foremost man-midwives, arrested development was a secondary cause that was implicated in the production of birth defects caused primarily by disease or other aetiologies. North noted that in cases of anencephaly the mother had often received a blow, or pressure to the abdomen, during pregnancy, which he thought could precipitate a developmental arrest[30]. The obstetrician James Y. Simpson used arrested development to explain hermaphroditism, an idea developed from his reading of William Harvey. He too supposed that, in many cases, developmental arrest was secondary to intrauterine disease[31]. Some physiologists also revived the Aristotelian concept of the female as a male in arrested development[32].

The theory was presented to an interested public through popular anatomical museums such as Sarti's in London. Sarti's catalogue promoted "arrest in development" as a cause of monstrosities and reconciled this with the maternal impressions theory, with which many visitors would have been familiar, by proposing a hybrid explanation whereby a striking visual stimulus during pregnancy could affect the mother's appetite, thereby indirectly leading to a developmental arrest of the foetus[33]. In medicine, the principle was applied by analogy to tissues as well as embryos: morbid changes of bones associated with restricted growth were attributed to arrested development[34].

Retrogressive Development

In Britain, the most notable early exponents of transcendental biology were the surgeon Joseph Green (1791-1863) and the anatomists Robert Grant (1827-74), Richard Owen and Robert Knox (1791-

1862), each of whom adapted it to their own socio-political views[35]. The most complete and overarching transcendental theories were those of Edinburgh-based lecturer Robert Knox, who after the failure of his anatomy school and a reluctant move to London made use of his enforced leisure time to deepen his researches into natural philosophy[36]. In a series of publications he elaborated a set of transcendental laws – expressed as "tendencies" – that he believed governed species change. In Knox's final formulation these laws were three: tendency to variety, tendency to heredity, and tendency to return to the type of the race or to perish altogether. Tendency to variety led the embryo to develop into a different type or species from the parent (the embryo was said to have the potential to produce any species, at least within its own natural family). This was counterbalanced by the hereditary tendency for offspring to resemble their parents, while a proclivity to return to the "type" of the race explained the propensity of crossbreeds to revert – over many generations – to one or other parent species, or to become infertile[37]. This model of intrinsic, oppositional forces driving development was characteristic of transcendentalism: there was no external cause of change distinct from nature, and some thought the doctrine pantheistic. Though Knox denied this, he also repudiated any possibility of purpose, directed change or successive improvement, which he felt implied a final cause[38] (Fig. 2).

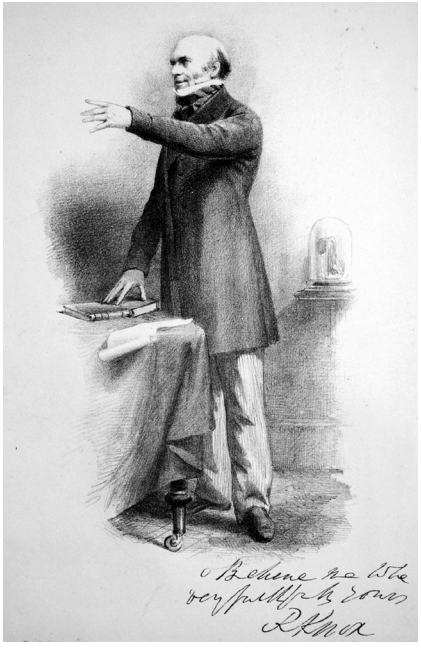

Fig. 2 - Dr Robert Knox lecturing

Knox was an ardent Francophile who had trained under Etienne Geoffroy St. Hilaire in Paris, but in many ways he was closer in thought to Georges Cuvier (1769-1832), and as a young man shared the latter's reluctance to accept transmutation of species, which without a plausible natural mechanism smacked of teleology. Knox also had misgivings about Isidore Geoffroy St. Hilaire's theory that monsters were due to arrested development, and in 1855 he admitted that, while he had taught it to his students for want of anything better, it had never satisfied him, though he was convinced that there must be a "law of deformation" that was as "regular" as the laws of formation. In other words, malformations were not structurally random but followed a pattern that the anatomist was tasked to discover. By 1855 he had developed a hypothesis that attributed some deformations of the embryo to "retrogressive development". Instead of seeing ontogeny as a linear process that could be halted prematurely, Knox envisaged a multiplicity of potential outcomes, some "inferior" to others, and therefore "retrogressive" when viewed from the perspective of human superiority, though each was "perfect in its way"[39]. Knox's eschewal of teleological arguments explains the apparent paradox in the term "retrogressive development". It was retrogressive in that it signified a return to forms previously existing or "lower" in the scale of organization, but still represented development as far as any change could in a system where no race or species was held to be more fully developed than another[40].

Knox was not an embryologist, and treated the embryo rather as a "black box", with the potential to follow one of many possible developmental pathways, the details of which were unspecified. Through shifts in the balance between an innate tendency to develop in the same way as its parents and opposing tendencies towards variation or reversion to type, the embryo could produce any possible species, including species that had not previously existed; indeed, one of the tenets of Knox's transcendentalism was that each embryo contained every possible adult form – past, present and fu-

ture – *in potentia*[41]. Theoretically, this was a much more liberating model that a linear passage through a series of ancestral forms in a prescribed order. Knox's model of nondirected, multipotent development allowed monsters to be incorporated into the temporal process of species change, anticipating later theories of evolution by macromutation[42]. These hopeful monsters became contiguous with normality, and their study was pursued in order to shed light on the causes of species change.

Knox's key example of retrogression was one of the most celebrated specimens in his collection, the "tiger arm", which was on display in his dissecting rooms as early as 1841, and which he often showed to visitors as "startling proof" of the strength of analogies between man and lower animals. The tiger arm – actually a human arm with an aberrant humeral foramen normally found in big cats – showed an anomaly that could not possibly be ascribed to developmental arrest, since no such foramen is observable in the human embryo at any stage. On the basis of this single case, Knox justified his rejection of arrested development in favour of "retrogressive developments"[43]. To understand the significance of what may appear to be a fine distinction, we must consider the third of Knox's transcendental laws, tendency to return to the type of the race.

In promulgating his third law, Knox was not advancing a novel hypothesis, but rearticulating the familiar law of atavism, a concept that had come to prominence in the nineteenth century due to increased scholarly interest in livestock and domestic animal breeding. When used in discussions of stockbreeding, atavism referred to recurrence of grandparental or older characteristics in offspring that differed from both parents. In scientific usage, it came to signify a recrudescence of ancestral characteristics after many generations (according to Huxley, atavistic characteristics were those of "long extinct progenitors")[44]. Retrogressive development of the embryo produced offspring that showed characteristics of ancestral forms, but not nec-

essarily forms that the embryo normally passed through during its development, thus it did not require acceptance of the theory of recapitulation. Whereas developmental arrest was ontogenesis stalled at an intermediate stage, retrogression represented a reawakening of latent developmental potential normally held in check by the tendency to heredity.

In his *Encyclopaedia Britannica* entry, Thomas Traill (1781-1862), an Edinburgh-based comparative anatomist who was one of the many butts of Knox's mockery[45], popularized retrogressive rather than arrested development by defining a monster as "a birth or production of a living being degenerating from the proper and usual disposition of the species to which it belongs …"[46]. Traill speculated that degeneration could operate as a secondary cause in monsters that were primarily caused by forces external to the embryo. By the end of the nineteenth century, retrogression had replaced arrested development as the dominant theory of teratogeny[47].

Regression was also applied outside embryology, as arrested development had been, as a pathogenetic mechanism of disease. In 1847, William Addison (1803-81) wrote an account in the *Lancet* of his "law of the morphology or metamorphosis of the textures of the human body" which interpreted disease processes in the light of Goethe's theory of unity of plan. One example of human "retrograde metamorphosis" was rickets – "the retrograde conversion of an osseous texture into a corpuscular one" – and Addison noted other conditions characterized by "replacement of a later or higher texture by one of an earlier or more primary type… as when the structure was evolving from its embryo state", a change reminiscent of the modern concept of dedifferentiation[48].

Retrogression and Species Change

Knox's interest in retrogression was primarily in relation to his theory of species change[49]. As long ago as 1837, Owen had suggested

to Darwin that the production of monsters was analogous to the production of species: according to Richards, Owen was disinclined to promote his own evolutionistic theories because of the critical reaction directed towards the author of *Vestiges of the Natural History of Creation*, but privately he favoured Hunter's explanation that monsters were inherent in the germ over the then prevalent Geoffroyan theory that they were caused by extrinsic factors[50]. Knox also looked to teratology for a model for the formation of new species, but whereas for Owen the forces involved were teleological ("*ordained becoming*")[51], Knox envisaged rapid species change due to development of the embryo, according to transcendental laws, into new forms that survived or perished according to the suitability of their environment[52].

Both men, along with many of their contemporaries, were understandably fascinated by the arrival in London of the "Aztec children", supposed survivors of a lost race whose abnormalities of the "brain case" Owen, in an advertisement for the exhibition, was said to have attributed to "arrested development"[53]. If this was truly his opinion, rather than just a "crafty puff" by their exhibitor, he quickly changed his mind, and at a special meeting of the Ethnological Society in London on 6 July 1853 he stated that the nearest thing anatomically to the Aztec children was the skull of an "idiot" preserved at St Bartholomew's Hospital[54]. As Owen later observed, maldevelopment could be a cause of idiocy even if "the embryo does not pass through the lower forms of animals"[55]. Knox used the children to support his own theory that atavism – "interrupted descent" – could lead to the reappearance of "lost" racial characteristics[56].

During his later years, Knox was best known for his work on race (after the posthumous adoption of his theories by anthropologists defending views of racial inferiority, his association with the subject became notorious) and although his interest in racial characteristics had been kindled by his early encounters with African races in the Cape Colony, he persevered in his studies throughout his life in the

hope that understanding racial change (he was a staunch monogenist – all humans shared a common ancestor) would enable him to solve the problem of species change. Indeed, since human races were regarded as species, racial change could be seen as the equivalent of species change in animals[57]. Knox did not assume that humans were the final term in an ascending series of all animal species, and so dismissed the notion that non-European races bridged the widely-perceived gap between humans and apes: "it is a great mistake to suppose that [these differences] indicate … a generic affiliation with any of the natural families of the higher orders of apes". Instead, he claimed that racial differences were "examples mostly of retrogressive development towards other races of animals whose forms are included in the embryo", and that the "peculiarities" exhibited by different races indicated retrogression towards ancestral forms rather than towards "lower animality" as represented by living apes[58]. This prudent phrasing appears calculated to spare the sensibilities of some readers while suggesting that humans were descendents of a common simian ancestor, rather than of any living ape.

Darwin was familiar with Knox's work though he seldom referred to it in print[59]. In *The Descent of Man* he discussed both arrested development and regression, though it is not clear if he had read Knox's paper on the latter subject. Basing his conclusions on the polygenist Carl Vogt's 1867 memoir on microcephaly, Darwin wrote that the resemblance between "microcephalous idiots" and the "lower types" of mankind, or even apes, could be seen as an example of "reversion", which was comparable to Knox's claim regarding the microcephalic Aztec children. Though retrogression was peripheral to Darwin's theories, he acknowledged its possibility. Objections were raised to natural selection on the grounds that some species differed in minor characteristics that could not affect survival, and the apparent tendency for disused parts to regress was particularly problematic since it was difficult to see how gradual

loss of redundant parts could be adaptive. Darwin claimed that fresh knowledge might reveal the adaptive benefits of all differences, but he also proposed "an innate tendency to retrogressive development" that could account for disappearance of parts in some "degraded" parasitic animals[60]. Such a tendency to regression could explain gradual change over many generations even if individual changes were non-adaptive[61]. Darwinism differed from Knox's hypothesis in its requirement for gradual, unidirectional change: nature could neither make a leap nor retrace her steps. Indeed, gradualism has been described as the central conviction of all Darwin's thought[62]. Knox, however, envisaged that retrogressive development might give rise to sudden, discontinuous throwbacks. In a single leap, the multipotent embryo could yield an ancestral form ready to occupy a suitable environment if one were available. Knox was therefore at odds with Darwin over both the rapidity of retrogression and its ability to restore lost forms[63].

An Uneasy Superiority

The politics of Darwinism has been the subject of considerable scholarly activity but less attention has been paid to the related theme of degeneration[64]. For some of Darwin's contemporaries, an attraction of natural selection was its nondirected progressiveness, an analogy for enlightened political and personal programmes of improvement[65]. By the late-nineteenth century, some commentators were addressing the contrary possibility, that species could "slip back down the evolutionary scale to prior states of development"[66]. In *Degeneration: A Chapter in Darwinism* (1880), which was based on observations of sea squirts, the invertebrate zoologist Ray Lankester (1847-1929) claimed that "if it was possible to evolve, it was also possible to devolve", an idea taken up by Grant Allen, the evolutionist and populariser of science who anthropomorphised the "retrogressive development" of the unfortunate ascidian:

The ascidian, however, in mature life, has grown degraded and fallen from his high estate, owing to his bad habit of rooting himself to a rock and there settling down into a mere sedentary swallower of passing morsels – a blind, handless, footless and degenerate thing[67] (Fig. 3).

Fig. 3 - Professor Ray Lankester, author of Degeneration: a Chapter in Darwinism (1880) in the Grant museum at University College London. © UCL, Grant Museum of Zoology.

This charming piece of writing hints at the thought that an entire species might regress. This was acknowledged as a possibility at a meeting of the Anthropological Society of London by the surgeon Walter Cooper Dendy (1794-1871), who offered it as a hypothesis in order to preserve the unique origin of humankind even if the so-called "missing link" were discovered, since, rather than showing progression from ape to human, "it might indicate degradation of species ... [f]avouring the notion of the Oceanic savage that the ape is a dwindled and degraded man"[68]. For those who accepted it, degeneration implied that man could not only progress but also regress to a subhuman level[69].

This theoretical potential for human regression, for reversion to animal type, had comparatively little impact in the field of biology; Knoxian saltatory evolution was lost sight of in post-Darwinian debates and though the reasons for this are many – Knox was too isolated, too radical and his proposals were published piecemeal – the social implications of saltatory evolution were a factor in its struggle for acceptance. Darwinism, with its insistence on gradualism, irreversibility and fitness was much more attuned to the values of the English bourgeoisie than Knoxian revolution, impermanence and chance. Retrogression did, however, take root in many other fields and, appropriately enough as Knox's theories can be located within the tradition of "moral anatomy", its implications were, from the beginning, as much social as biological[70].

On the Continent, others were pursuing the potential of degeneration independently of Knox. In 1857 the French physician and alienist Bénédict Morel (1809-1873) published his influential treatise on human degeneration, which popularized the concept of progressive acquired mental degeneration to a primitive state[71]. By the 1870s, British doctors were applying similar thinking to disorders of the mind: in the Gulstonian Lecture delivered at the Royal College of Physicians in London in 1870, the asylum doctor Henry Maudsley (1835-1918) spoke of "a brute brain within the man's.". If the brain

stopped short in its intellectual development, men would display primitive "animal traits"[72]. The final step from physical degeneration through mental regression to a purely psychological deterioration was the suggestion that moral fibre acquired through education and religious instruction could be lost through relapse into a more primitive mindset that privileged sense experience over spirituality. The 1868 translation of Julius Muller's *The Christian Doctrine of Sin* refers to the risk of "advancing degeneracy" when the sensational obtains dominance over the spiritual[73].

Such changes were individual degenerations of the mind, but in Britain there was also speculation on degeneration of entire populations. In 1863, the discussion at the Anthropological Society, which was heavily influenced by Knoxian ideas, was on the causes of habitual cannibalism in "savages". Cannibalism, it was suggested, could not be "the mere result of uncivilisation" but was attributable to arrested development, which left some races with "all the bloodthirstiness of the carnivore"[74].In other words, cannibalism was not a state into which any man might lapse without the constraints of civilization; the cannibal savage was congenitally underdeveloped and lacked the capacity to become civilised. If such races were "weaned" from cannibalism by missionaries they could not maintain "civilized" life for long without "retrogression"[75]. Nor were Europeans exempt from retrogressive tendencies; there was speculation that degenerate modern humanity had, in a biological recapitulation of the fall of Adam, suffered a "morbid deviation from an original type"[76], and Lankester extended his theory of biological degeneration to the social world to argue for educational and social reform[77]. If Europeans were intellectually superior to savage races, theirs was an uneasy superiority.

Psychiatric and criminological notions of degeneracy were critical to British social debates in the late-nineteenth century and beyond[78]. Degeneracy was the scientized fear of reversion, which haunted

Gothic romance from its eighteenth-century beginnings and which held late-Victorian Britain in a state of anxiety that has been likened to panic[79]. Its apotheosis was Stevenson's ape-like, subhuman Hyde who usurps the upright, repressed Jekyll. Its origins lay in the transcendental taxonomy of monsters[80].

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16. APPEL T., *The Cuvier-Geoffroy Debate: French Biology in the Decades Before Darwin*. Oxford, Oxford University Press, 1987, p. 106. Transcendentalism is linked to Christian mysticism historically – e.g. through Emanuel Swedenborg's influence on Goethe - and in North America it was associated with Unitarianism: ELLIS G.E., *A Half-Century of the Unitarian Controversy: With Particular Reference to its Origin, its Course and its Prominent Subjects*. Boston, Crosby, Nichols and Co., 1857, pp. 412-414.
17. SLOAN P.R., *Kant on the History of Nature: The Ambiguous Heritage of the Critical Philosophy for Natural History*. Stud. Hist. Phil. Biol. Biomed. Sci. 2006; 37: 627-648.
18. See CORSI P., *Idola Tribus: Lamarck, Politics and Religion in the Early Nineteenth Century*. In: FASOLO A. (ed.), *The Theory of Evolution and its Impact*. Milan, Springer, 2012, pp. 11-40.
19. BURNS J.H., *John MacVicar and the Economy of Nature*. Intell. Hist. Rev. 2009; 19: 319-335.
20. DESMOND A.J., *The Politics of Evolution: Morphology, Medicine, and Reform in Radical London*. Chicago, University of Chicago Press, 1992, pp. 94-100.
21. Geoffroy aimed to classify them according to a Linnaean style binomial nomenclature: APPEL T., ref. 16, p. 126. See also PARK K. and DASTON L.J., *Unnatural Conceptions: Monsters in Sixteenth- and Seventeenth-Century France and England*. *Past and Present* 1981;92:20-54. The phrase "taxonomy of monsters" was first applied to fictional monsters: BRIERLY K., *Brierly's Taxonomy of Monsters*. Instructor 1977; 86: 74-78.
22. ANON., *On Monstrosities in General*. Med. Chir. Rev. 1836; 24: 209-215.
23. GEOFFROY SAINT-HILAIRE I., *Histoire générale et particulière des anomalies de l'organisation chez l'homme et les animaux*. Paris, J-B. Baillière, 1832, vol. I, p. 19.

24. BLANDIN P.F., *Traité d'anatomie topographie, ou anatomie des régions du corps humain*. Paris, Germer-Baillière, 1834, p. 7.
25. ANON., *A Treatise on Pathological Anatomy*. Lancet 1830; 1: 922-6; OWEN R., *On the Osteology of the Chimpanzee and Orang Utan*. Proc. Zool. Soc. Lond. 1835; 1: 343-380.
26. BOULTON T., see ref. 7.
27. *Penny Cyclopaedia of the Society for the Diffusion of Useful Knowledge*. London, Charles Knight and Co., 1839, vol. XV, p. 348.
28. NORTH J. *A Lecture on Monstrosities*. Lancet 1840; 1: 857-862, 913-919.
29. By the mid-nineteenth century many medical men regarded maternal impressions as superstition: ANON., *Popular medical errors*. Med. Times Gaz. 1863; 2: 617-618. In 1865 the physician Alfred Meadows argued in favour of maternal impressions, observing that the connection between mind and matter in any field defied explanation: MEADOWS A., *Case of Monstrosity, with Remarks on the Influence of Maternal Impressions on the Foetus in Utero*. Trans. Obstetr. Soc. Lond. 1865; 7: 84-94.
30. NORTH J., see ref. 28.
31. SIMPSON J.Y., *Obstetric Memoirs and Contributions*. (ed. PRIESTLEY W.O. and STORER H.R.) Edinburgh, Adam and Charles Black. 1856, vol. II, pp. 344-345.
32. See GIRDWOOD G.F., *On the Theory of Menstruation*. Lancet 1844; 2: 312-316. Knox noticed similarities between the foetal pelvis and that of the adult female: ANON., *Labour*. Br. For. Med. Rev. 1844; 17: 535-539.
33. MAWHINNEY W., *Anatomical and Physiological Description of Signor Sarti's Florentine Venus, Together With the Causes, Symptoms, and Treatment of the Diseases of the Principal Organs*. Bury, John Heap, 1851, pp. 37-38. Attempts to devise a plausible mechanism through which maternal impressions could act continued for some decades, e.g. O'REILLY J., *The Nervous and Vascular Connection Between the Mother and Foetus in Utero*. New York, Robert Craighead, 1864, p. 76.
34. LITTLE W.J., *Hospital for the Cure of Deformities: Course of Lectures on the Deformities of the Human Frame*. Lancet 1844; 1: 564-8. On applications of arrested development outside natural history see GOULD S.J., see ref. 2, pp. 115-166.
35. RICHARDS E., *"Metaphorical Mystifications": The Romantic Gestation of Nature in British Biology*. In: CUNNINGHAM A. and JARDINE N. (eds), see ref. 11, pp. 130-143.

36. REHBOCK P.F., *The Philosophical Naturalists: Themes in Early Nineteenth-Century British Biology*. Madison, University of Wisconsin Press, 1983, pp. 31-55.
37. Richards concluded that *The Races of Men* advocated "a common material origin of life and its evolution by a process of saltatory descent"; i.e. new species arose not by gradual change but by single-step speciation: RICHARDS E., *A Political Anatomy of Monsters, hopeful and otherwise: Teratogeny, Transcendentalism, and Evolutionary Theorizing*. Isis 1994; 85: 377-411, p. 389.
38. BATES A.W., *The Anatomy of Robert Knox: **Murder, Mad Science and Medical Regulation in Nineteenth-Century Edinburgh***. Brighton, Sussex Academic Press, 2010, p. 138. The American spiritualist author Andrew Jackson Davis, who had been influenced by Swedenborg, wrote of an "immutable Law" that pervades all matter and produces all things by its "progressive unfoldings". This resembles Knox's laws of development though Davis, unlike Knox, was a progressivist. Davis also recognized a tendency towards retrogression in animals, which had degenerated in their natures, qualities and habits since previous eras; he supposed they would be replaced by newer, more perfect species: DAVIS A.J., *The Principles of Nature, Her Divine Revelations, and a Voice to Mankind*. Boston, Colby and Rich, 1847, pp. 151, 304.
39. KNOX R., *Contributions to the Philosophy of Zoology, with Special Reference to the Natural History of Man*. Lancet 1855; 2: 382-392.
40. See KNOX R., see ref. 39, p. 385. Humans appeared from their own perspective to be the most developed species, but if fossil fishes had left records, Knox observed, they too would have thought themselves the finest of Nature's works: KNOX R., *A Manual of Artistic Anatomy, for the use of Sculptors, Painters and Amateurs*. London, Henry Renshaw, 1852, p. 153. Other naturalists had written of degeneration – for example J.F. Blumenbach in his *Manual of the elements of Natural History* and Georges Buffon on "la degeneration des animaux" in his *Histoire naturelle*, but in these earlier theories degeneration of species or races implied decline or deterioration and did not give rise to viable new organic kinds: see EDDY J.H., *Buffon's Histoire naturelle: History? a critique of recent interpretations*. Isis 1994; 85: 644-661.
41. See Goethe's conjecture that "the germ of any animal" was, potentially, "the germ of every other:" KNOX R., see ref. 39, 2: 216–218.
42. GOULD S.J., The Return of Hopeful Monsters. Nat. Hist. 1977; 86: 22-30.
43. RICHARDS E., see ref. 37, p. 389.

44. HUXLEY T.H., *Evidence as to Man's Place in Nature*. Edin. Rev. 1863; 117: 278-293, p. 284.
45. LONSDALE H., *A Sketch of the Life and Writings of Robert Knox, the Anatomist*. London, Macmillan and Co., 1870, pp. 174-175.
46. TRAILL T.S., *Monster.* In: *Encyclopaedia Britannica*. Edinburgh, Archibald Constable and Co., (6th edn) 1823, vol. XIV, pp. 341-344.
47. SALEEBY C.W., *Heredity*. New York, Frederick A. Stokes, 1900, p. 67.
48. ADDISON W., *The Law of the Morphology or Metamorphosis of the Textures of the Human Body*. Lancet 1847; 1: 252-253.
49. Transcendentalism revisited and reversed the Aristotelian view of the female as an imperfect male. In comparison with animal forms, the female appeared the more developed and was aesthetically superior to the male, as evinced by the greater resemblance of male anatomy to infantile or lower animal forms: ANON., *M. Cruveilhier on the Doctrine of Arrested Development*. Med. Chir. Rev. 1839; 31: 201-203; ANON., *The Plan of the Universe, III: On the Inherent Superiority of the Female Element in the Scheme of Creation*. Future 1860; 1: 65-74.
50. RICHARDS E., see ref. 37, p. 394-395.
51. *Ibid*. p. 401.
52. Knoxian species change differed from Darwinism in that survival of the fittest was not the driving force for change: new species arose fully distinct from their parents and either survived or perished.
53. STEPHENS J.L., *Illustrated Memoir of an Eventful Expedition Into Central America Resulting in the Discovery of the Idolatrous City of Iximaya and the Possession of Two Remarkable Aztec Children, Maximo & Bartola*. New York, Wynkoop, Hallenbeck and Thomas, 1860, pp. 5-6.
54. OWEN R. and CULL R., *A Brief Notice of the Aztec Race, followed by a Description of the So-Called Aztec Children Exhibited in 1853*. J. Ethnol. Soc. 1856; 4: 120–137.
55. Quoted in MOORE G., *The First Man and His Place in Creation*. London, Longmans, Green and Co., 1866, p. 96.
56. KNOX R., *Some Remarks on the Aztecque and Bosjieman Children, now being exhibited in London*. Lancet 1855; 1: 357-360.
57. At the time, species meant something like subspecies in modern terminology and a genus was closer to what would now be called a species.
58. KNOX R., see ref. 56, p. 359.
59. DARWIN C., *The Descent of Man: And Selection in Relation to Sex*. London, John Murray, 1871, vol. I, pp. 23, 28, 217.

60. DARWIN C., *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (5th edn). London, John Murray, 1869, p. 155. On Darwinism and degeneration see: GOULD S.J., *The Structure of Evolutionary Theory*. Cambridge MA, Belknap Press, 2002, pp. 203-208.
61. While Darwin downplayed the role of innate tendencies, they offered, in the hands of St George Mivart FRS, a potential means to reconcile natural selection with divine purpose: while admitting the operation of natural selection, he made it subordinate to natural laws tending towards progressive development: MIVART St G., *On the Genesis of Species*. New York, D. Appleton and Co., 1871.
62. GOULD S.J., *Structure*, pp. 148-149. Huxley regarded Darwin's insistence on *natura non facit saltum* as an unnecessary difficulty: letter to Darwin, 23 Nov. 1859. Cambridge University Library, Darwin Papers 98: B11-13. The principle that an organism is unable to return even partially to an ancestral state was enshrined in Dollo's law: DOLLO L. *Les lois de l'évolution*. Bull. Soc. Belg. Geol. Pal. Hydr. 1893; 7: 164-166. Cf. DARWIN C.,see ref. 60, p. 276.
63. Saltationism is, however, compatible with adaptionism: ARIEW A., *Natural Selection doesn't work that Way: Jerry Fodor vs. Evolutionary Psychology on Gradualism and Saltationism*. Mind and Language 2003; 18: 478-483.
64. PICK D., *Faces of Degeneration: A European Disorder c.1848-1918*. Cambridge, Cambridge University Press, 1989, p. 6.
65. KOHN D. (ed.), *The Darwinian Heritage*. Princeton, Princeton University Press, 1988; DESMOND A.J., see ref. 20.
66. LUCKHURST R., *Late Victorian Gothic Tales*. Oxford, Oxford University Press, 2005, p. 20.
67. ALLEN G., *The Evolutionist at Large*. London, Chatto and Windus, 1881, p. 100-101.
68. ANON., *Minutes 17th November 1868*. J. Anthropol. Soc. 1869; 7: 34-38.
69. For an argument against reasoning from single anomalies to atavism of a species see VIRCHOW R., *The Cranial Affinities of Man and the Ape*. Boston, Lee and Shepard, 1871, pp. 46-49.
70. RICHARDS E., *The "Moral Anatomy" of Robert Knox: The Interplay between Biological and Social Thought in Victorian Scientific Naturalism*. J. Hist. Biol. 1989; 22: 373-436.
71. MOREL B.A., *Traité des dégénérescences physiques, intellectuelles et morales de l'espèce humaine et des causes qui produisent ces variétés*

maladives. Paris, J.-B. Baillière, 1857; BOWLER P.J., *Holding your head up high: Degeneration and orthogenesis in theories of human evolution*. In: MOORE J.R. (ed.), *History, Humanity and Evolution: Essays for John C. Greene*. Cambridge, Cambridge University Press, 1989, pp. 328-354.
72. MAUDSLEY H., *Gulstonian Lectures on the Relations between Body and Mind and between Mental and Other Disorders of the Nervous System*. Lancet 1870; 1: 609-612.
73. MULLER J., *The Christian Doctrine of Sin*. (Transl. URWICK W.) Edinburgh, T. and T. Clark, 1868, vol. I, p. 299.
74. ANON., *Anthropological Society of London*. Med. Times Gaz. 1863; 1: 359.
75. FARRAR F.W., *Aptitudes of Races*. Trans. Ethnol. Soc. Lond. 1867; 5: 115-126.
76. BEER D., *Renovating Russia: The human sciences and the fate of liberal modernity, 1880-1930*. Ithaca, Cornell University Press, 2008, p. 36.
77. BARNETT R., *Education or Degeneration: E. Ray Lankester, H.G. Wells and the Outline of History*. Stud. Hist. Phil. Sci. C 2006; 37: 203–229.
78. PICK D., see ref. 64.
79. VALENTE J., *Dracula's Crypt: Bram Stoker, Irishness, and the Question of Blood*. Illinois, University of Illinois Press, 2001, p. 5; LUCKHURST R., see ref. 66, p. xx; WYNNE D., *The Sensation Novel and the Victorian Family Magazine*. Basingstoke, Palgrave. 2001, p. 86.
80. See RICHTER V., *The Civilized Ape*. In: MOHR D.M. (ed.), *Embracing the Other: Addressing Xenophobia in the New Literatures in English*. Amsterdam, Rodopi, 2008, pp 113-125.

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