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## Art, anatomy, and the stars

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## 1 Art, Anatomy, and the Stars: Russell and Séguin's Dinosauroid

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Abstract: It takes a bold, innovative mind to publish an exercise in speculative evolution 13 pertaining to an alternative timeline. Dale Russell's studies of the troodontid 14 Stenonychosaurus and of ornithomimid theropods, published in 1969 and 1972, inspired him 15 to consider the possibility that some theropod dinosaur lineages might have given rise to big-16 brained species had they never died out. By late 1980, Russell had considered the invention 17 of a hypothetical descendant of Stenonychosaurus dubbed the 'dinosauroid'. There is likely 18 no specific inspiration for the dinosauroid given Russell's overlapping areas of interest, but 19 his correspondence with Carl Sagan and his involvement in the SETI programme were likely 20 21 of special influence. The early-1980s creation of a life-size Stenonychosaurus model with Ron Séguin gave Russell the impetus to bring the dinosauroid to life. Authors have disagreed 22 on whether the dinosauroid's creation was an exercise in scientific extrapolation or one of 23 24 speculative fiction, and on whether its form reflects bias or an honest experiment: Russell justified his decisions on the basis of the dinosauroid's anatomy being adaptive and linked to 25 efficiency, but he also stated or implied that the human form may be considered a predictable 26 27 evolutionary outcome among big-brained organisms, and expressed a preference for directionist views which posit humans as close to the pinnacle of evolution. Both derided and 28 praised at the time of its construction, the dinosauroid is undergoing a resurgence of interest. 29 Given that its aim was to spark discussion and invite alternative solutions, it can only be 30 considered an extraordinary success. 31

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33

#### 35 Introduction

36

37	"Probably it's a real period piece, and full of mistakes. But whether it's completely
38	wrong or not, it does somehow say what I feel at night when I look up into the
39	boundless vault of a soft, star-filled prairie sky."
40	- Dale Russell to Steven Mark, April 15 <sup>th</sup> 1984 <sup>1</sup>

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These words, adapted from a talk given in 1983, conclude Dale Russell's reaction to the view 42 of evolutionary history drawn using his 'dinosauroid' thought experiment (Fig. 1). Reading 43 them, we can find the same combination of scientific rigour and imaginative bravado which 44 made the dinosauroid itself both so controversial and so appealing. The first sentence worries, 45 responsibly, about how quickly the work would date - not quite two years after the 46 publication of the dinosauroid paper, which itself had stressed the tenuousness of the 47 hypothesis (Russell and Séguin 1982, p. 35). In the second sentence, though, these scruples 48 are laid aside through an appeal to the powerful if disreputable mechanism of *instinctive* 49 truth: "what I feel at night", here, replaces the practice of science with the subjective, human 50 experience of being a scientist (and, perhaps, of other worldviews). The passage usefully 51 introduces some of the other keynotes of the dinosauroid project. Evoking the arts (through 52 language like "period piece" as well as through the appeal to the Romantic image of the 53

<sup>&</sup>lt;sup>1</sup> All dated correspondence cited in this article can be found in Russell's collection at the Archives of the Canadian Museum of Nature (CMN).

individual contemplating the universe) hints at Russell's firm belief in the value of 54 collaborating with visual artists (espoused forcibly in several of Russell's works, most 55 notably Russell 1987). The image of the "boundless vault" of the stars suggests the 56 importance of exobiology and space exploration in the history of an idea supposedly "based 57 entirely on 'endobiological' (terrestrial) evidence" (Russell to J. Kevin Ramos, Sept 14th 58 1984). This is bolstered by the word "prairie", which serves not only to place Russell in 59 60 dinosaur country but, as part of the phrase "prairie sky", to superimpose the mysteries of deep space upon those of the fossil-bearing Albertan rocks. 61

Russell's correspondent Steven Mark was an entertainment lawyer and aspiring 62 screenwriter and producer, and the two were writing about the project which would become 63 Dinosaur! (1985), a documentary presented by Christopher Reeve and featuring animations 64 by Phil Tippett, who had worked on Star Wars and would go on to oversee the dinosaurs of 65 Jurassic Park (1993). Towards the end of that documentary, a discussion of the end-66 Cretaceous extinction segues into the question: "How might the dinosaurs have evolved if 67 they hadn't disappeared?". Russell appears on screen, strolling from his (and Ron Séguin's) 68 life-sized reconstruction of the Late Cretaceous theropod dinosaur Stenonychosaurus -69 70 featured against a scrubland diorama - to the sculpture of the humanoid reptile provocatively posed behind a normal office desk, a dartboard tucked discreetly behind its legs. "[I]n the 71 72 sixty-five million years that separates the end of the dinosaurs from ourselves", Russell says to the camera, "it is quite legitimate to speculate that some of the largest-brained dinosaurs 73 may have looked something like this creature here" (Guenette 1985). 74

It's always towards the end. In Russell's *An Odyssey in Time* (1989), the speculative
evolution arrives on page 213, almost as a coda to the main discussion. In another
documentary called *Dinosaur!*, this one a four-part 1991 series fronted by Walter Cronkite,

dinosauroids (portrayed by humans in costume) take over for a minute towards the close of 78 the final episode; the accompanying book (Norman 1991) discusses the dinosauroid only on 79 its very last page. In Louie Psihoyos and John Knoebber's popular Hunting Dinosaurs, the 80 dinosauroid turns up in the last chapter, which is suggestively titled 'Picking Up the Pieces' 81 (Psihoyos and Knoebber 1994, 251). A recent magazine piece called 'What if dinosaurs 82 hadn't died out?', brings in Russell and Séguin's hypothesis, "which today looks like an alien 83 84 from a dated sci-fi show", only in paragraph 29 of 34 (Pickrell 2017). Even in the original scientific paper - 'Reconstructions of the small Cretaceous theropod Stenonychosaurus 85 86 inequalis and a hypothetical dinosauroid' - it's only the last four words of the title which introduce our protagonist, and after the abstract and introduction, the speculative evolution is 87 not discussed or mentioned until the end of page 21 (Russell and Séguin 1982). The 88 dinosauroid, it seems, is always an afterthought or, better, an envoi, a conclusion gesturing 89 90 forwards, hinting at something which the form of the responsible textbook, documentary, or magazine article can only flirt with. 91

Precisely because of its place on the threshold of respectability, the dinosauroid project 92 has been largely successful in achieving Russell's aim of galvanising wider conversation 93 about speculative evolution. In this essay, we take stock of that success by describing the 94 project itself, then by reviewing its intellectual origins (especially with reference to the SETI 95 96 programme), and finally by sketching its influence on popular and scientific culture: an influence which continues (and is arguably rising) at the time of writing. The dinosauroid and 97 its implications have already been the subject of substantial commentary and review (Hecht 98 and Williams 1982; Raup 1985; Norman 1986, 1991; Dixon 1988; Paul 1988; Lambert 1990; 99 100 Magee 1993; Psihoyos and Knoebber 1994; Mayor 2000; Debus and Debus 2002; Hecht 2007; Naish 2008; Shuker 2008; Socha 2008; Switek 2010; Losos 2017; Pickrell 2017; Burke 101

and Tattersdill in press); keen not to tread over old ground, our discussion explores several
neglected aspects of its backstory, thanks in part to the access we have had to Russell's
papers, archived at the Canadian Museum of Nature (CMN, formerly National Museum of
Natural Sciences). It remains unclear whether all of Russell's correspondence relevant to the
dinosauroid survived a cull which occurred once Russell left the CMN for North Carolina but
we are pleased to introduce some new observations from what does survive, and also to
include images of the dinosauroid project which have not previously seen print.

With regard to some necessary issues of technical terminology, the dinosaur which 109 inspired the dinosauroid project is Stenonychosaurus inequalis from the Campanian Dinosaur 110 Park Formation of Alberta (Russell 1969), though note that this unit had not been separated 111 from the older Oldman Formation at the time Russell was working (Eberth and Hamblin 112 1993). Currie (1987) argued that S. inequalis should be absorbed into the synonymy of 113 Troodon inequalis, a taxon based on a tooth but regarded as diagnosable and valid by Currie 114 (1987). Most post-1987 discussions of the dinosauroid therefore refer to its ancestor as 115 Troodon, not Stenonychosaurus. A nomenclatural outcome of the recognition of Troodon as a 116 maniraptoran theropod is that the mostly Cretaceous theropod group which includes 117 Stenonychosaurus is today termed Troodontidae, but it was known as Saurornithoididae when 118 Russell was working, so a similar shift affected the name of the group regarded as ancestral 119 120 to the dinosauroid (viz, from saurornithoidid to troodontid). Russell referred to the members of this group as 'saurornithoids' (Russell and Séguin 1982), perhaps - we speculate - because 121 it complements 'dinosauroids'. It has more recently been argued that Troodon is best 122 regarded as a nomen dubium since its supposedly diagnostic tooth characters have now been 123 documented in more than one troodontid taxon (Evans et al. 2017; van der Reest and Currie 124 2017). This decision has led some authors (Evans et al. 2017; van der Reest and Currie 2017) 125

to revalidate *Stenonychosaurus* and advocate abandonment of *Troodon* for good North
American troodontid remains; a dissenting opinion, however, posits that *Troodon* should be
retained in view of its widespread use (Varricchio et al. 2018). Finally, it should be noted that
the relegation of *Troodon* to *nomen dubium* status does not, according to Article 35 of The
International Code of Zoological Nomenclature (International Commission on Zoological
Nomenclature 1999), nullify use of the family name Troodontidae.

132

#### 133 The anatomy, design, and construction of the dinosauroid

The question which provoked the dinosauroid into existence is a simple and arresting one: what if non-bird dinosaurs hadn't gone extinct? In their *Syllogeus* paper, the research organ of the CMN which published new work rapidly and without peer review, Russell and Séguin present the question as arising naturally from observations about saurornithoidid intelligence. Having restored a specimen of *Stenonychosaurus inequalis* and noted that it lived about twelve million years before the K-Pg mass extinction, they wrote:

140

141	It would be fascinating to learn how the saurornithoid attributes of large brain
142	size, stereoscopic vision, opposable fingers and bipedal stature changed, if at
143	all, during the remainder of Mesozoic time. It might also be entertaining to
144	speculate in a qualitative manner on how the descendants of S. inequalis might
145	have appeared had they survived the terminal Mesozoic extinctions, and
146	achieved an encephalization quotient similar to that of Homo sapiens
147	(Russell and Séguin 1982, p. 22).

148

This moment, at the halfway point of the paper, forms the hinge between rigorous scientific 149 150 work and something more speculative: the question underlying the first sentence could conceivably be answered one day with the discovery of new remains (and, indeed, can now 151 be considered answered given more recent finds of troodontids from the terminal Cretaceous; 152 153 e.g., Kurzanov and Osmólska 1991; Fiorillo and Gangloff 2000; Averianov and Sues 2007), but in the second sentence we advance beyond the realm of the strictly empirical. The 154 conditional language ("It would be", "It might be", "might have appeared") belies the very 155 definite work which Russell and Séguin have already done, leaving the dinosauroid off-156 handed and provisional even as it moves to introduce carefully-figured details. The shift from 157 "fascinating" to "entertaining" is also suggestive, a self-effacement anticipating likely 158 objections to the unorthodox question and methodology. With these linguistic maneuvers, 159 and the authority afforded by the Stenonychosaurus part of the paper, Russell and Séguin 160 161 ease the reader into the dinosauroid hypothesis.

This, simply put, is that "the human form is not an evolutionarily surprising form. It may 162 represent a target that is easy for natural selection to hit" (to quote Russell from his April 163 1984 correspondence to Steven Mark). Working towards this point - although never quite 164 stating it outright - the Syllogeus article provides substantial insight on the dinosauroid's 165 166 anatomical configurations and the speculative evolutionary back story to its design (Russell and Séguin 1982, pp. 22-26; some of this is summarized in Russell 1989). The dinosauroid, 167 incidentally, was - at one point, at least - going to be labelled Dinosauroides erectus, the 168 descendant of the less specialized D. horizontalis (according to text Russell sent to Steven 169 Mark in April 1984). 170

Without downplaying the dinosauroid's novelty, it should be noted that the 'smart dinosaur' trope was already in the air during the 70s, in part because of Russell's (1969, 1972) comments on theropod brain size and encephalization, but also because of new ideas on dinosaur biology (including endothermy and nocturnal mammal-hunting) and extinction. Beyond the sciences, there are also considerable precedents for the dinosauroid in midtwentieth century science fiction: a fact we return to later. First, though, we review some of the dinosauroid's immediate neighbours in the sciences.

A seminal work on the dinosaur renaissance – Adrian Desmond's The Hot Blooded 178 Dinosaurs (Desmond 1975) – includes in its final chapter: "The potential inherent in 179 dromaeosaurs and coelurosaurs for an explosive evolution as the Tertiary dawned cannot be 180 doubted - who knows what new peaks the sophisticated 'bird-mimics' would have attained 181 had they survived into the 'Age of Mammals'" (p. 185). Indeed, imaginary smart dinosaurs 182 were, at about this time, developed simultaneously by several authors. Harry Jerison - whose 183 data on encephalization in vertebrates (Jerison 1973) was integral to Russell's speculative 184 thoughts on troodontids (Russell and Séguin 1982, p. 21) – floated the idea that brainy 185 theropods were an evolutionary possibility in a Fellows' Address ('Smart dinosaurs and 186 comparative psychology') given at the American Psychological Association meeting in 187 Toronto in August 1978. Jerison's animals of choice were ornithomimids like 188 189 Dromiceiomimus (coincidentally, a taxon named by Russell), and he postulated a hypothetical D. sapiens. These musings were never published, and Russell (1987, p. 127) 190 noted that he was unaware of them "until several years later". McLoughlin (1984) devised a 191 big-brained, post-Cretaceous theropod close in time to Russell and Séguin, likely being fully 192 aware of Russell's work, a contention we make based on the contents of McLoughlin's later 193 sci-fi works (McLoughlin 1983; McLoughlin 1987). We know that Russell was aware of 194

McLoughlin's article since he was sent a copy by Michael Morales of the Museum of 195 Northern Arizona in September 1984. McLoughlin's (1984) big-brained theropod is a 196 dromaeosaurid rather than a troodontid, and is long-tailed and not humanoid. In view of these 197 alternative 'smart dinosaurs', it is worth pinning down the dinosauroid's 'date of origin' as 198 precisely as possible. A December 1980 letter from Ralph Molnar, based at the time at the 199 Queensland Museum, reveals that Russell was referring in correspondence to his dinosauroid 200 201 project at this time or slightly before, but was being cryptic about it. In the letter, Molnar notes his keenness to see the reconstructed "hypothetical potential theropod" which Russell 202 203 was working on (Molnar must have been referring to a physical model rather than an illustration since Russell's skeletal reconstruction of Stenonychosaurus was published in 204 1969; Russell 1969). 205

206 If the dinosauroid has come to eclipse its near-contemporaries, it has also in many senses eclipsed the other reconstruction which appeared alongside it: little commentary has appeared 207 on the Stenonychosaurus model (Fig. 2) bar notes provided by Paul (1988). The 208 Stenonychosaurus (which lacks feathers and is covered in scaly skin, as thought correct at the 209 time) is accurate in posture, proportions and nuance, and mirrors the appearance of this 210 dinosaur established in Russell's papers (Russell 1969). Its ribcage is broad and bulky 211 relative to what is now considered accurate (based on articulated troodontids: Russell and 212 213 Dong 1994; Tsuihiji et al. 2014); in the hand, it was constructed as if capable of manual pronation and of having a rotated digit III which was opposable to digit I (cf Russell 1969, p. 214 603). Neither of these forelimb features are consistent with articulated maniraptoran hands 215 nor our understanding of digital movement in these dinosaurs (Gishlick 2001; Senter 2006), 216 though it should be noted that this has only become obvious thanks to studies published post-217 2000. An interesting detail in the feet is that the hyperextendable digit II was shown as being 218

held in a flexed position on the right foot (a hyperextended posture expected for these
dinosaurs was depicted on the left side): this is not an error, but is consistent with the
extensive movement possible in this digit.

Paul (1988, p. 398) regarded the model as insufficiently muscled in the hindlimbs and 222 "overly scrawny"; it should be noted that the 'shrink-wrapped' look of the animal is in 223 keeping with the appearance of other dinosaurs supervised by Russell (viz, those of Ely Kish) 224 and is not specific to this one in particular. Russell evidently liked his dinosaurs skeletally 225 thin, lacking fat, and with minimal muscular bulk. Regardless, the fact that Séguin's 226 Stenonychosaurus is accurate overall and – bar the specifics noted here, integument 227 especially – not inconsistent with modern thinking on the life appearance of these animals, 228 means that both it and the dinosauroid can be perceived as up to date views of their 229 appearance, and not contingent on the traditions of the early 1980s. 230

Turning now to the form of the dinosauroid (Fig. 3), the evolution of an enlarged skull 231 was suggested as the primary driver for the development of verticalized thorax and its 232 centralized position on a shortened neck; additionally, the increased energetic efficiency of 233 erect-bodied, human-style locomotion and the improvements it would allow in throwing 234 projectiles and using tools were cited as reasons for a human-like form (Russell and Séguin 235 1982, p. 26). Several references to the literature on hominid evolution were made to provide 236 237 justification for these proposals, including works by Roger Lewin, Peter Rodman and Henry McHenry, and Sherwood Washburn (Russell and Séguin 1982); of incidental interest is that 238 Russell sometimes mentioned Louis Leakey, Donald Johanson and their work in connection 239 with the Stenonychosaurus remains he described in 1969 (Hecht and Williams 1982, p. 50; 240 Psihoyos and Knoebber 1994). In relating the time that Leakey examined the remains, 241 Russell's implication was that Russell and Leakey both noticed, independently, the potential 242

243 *Stenonychosaurus* might have to give rise to bigger brained descendants (Psihoyos and
244 Knoebber 1994, p. 251).

The dinosauroid's endocranial volume is 1100 ml (derived by comparing the model skull 245 to that of a small female human); its encephalisation quotient (EQ) – a ratio of brain to body 246 size - was stated to be 7.1 (Russell and Séguin 1982, p. 27). It is clear from citations 247 248 throughout Russell and Séguin (1982) that Jerison's (1973) graph was relied on in order to calculate the dinosauroid's EQ, and we assume that a human-like brain size was used such 249 that the dinosauroid would end up with a human-like EQ, stated by Russell and Séguin (1982, 250 p. 22) to be "about 7.5", following Jerison (1973). However, Jerison's (1973) EQ data 251 grouped vertebrates into 'higher vertebrate' and 'lower vertebrate' categories alone, his 252 assumption being that vertebrates of diverse and disparate groups should fit on the same 253 slope. This cannot be true given that average brain to body size ratios differ among vertebrate 254 groups. In recognition of this, Hurlburt (1996) developed revised EQ formulae for non-bird 255 reptiles (REQ), birds (BEQ) and mammals (MEQ) and used a much larger range of species 256 than Jerison (1973). We were interested in comparing the dinosauroid's EQ to that of 'real 257 timeline' dinosaurs and other animals in view of this revised, post-Jerison (1973) work, some 258 259 of which has already revised EQ data on Cretaceous theropods (Hurlburt et al. 2013). The dinosauroid has an REQ of 244.08, BEQ of 22.12, and MEQ of 8.9555. For comparison, H. 260 261 sapiens has an REQ of 190.71, BEQ of 16.74, and MEQ of 5.8976 (G. Hurlburt, personal communication, 2020). The dinosauroid, then, is not simply brainy; it is astronomically 262 brainy, well exceeding the EQs of all other analysed dinosaurs (including the highest-EQ 263 living birds, like parrots: the macaw Ara has a BEQ of 2.986) as well as humans (Hurlburt 264 1996; Hurlburt et al. 2013). It does not fit on the slopes established for non-bird reptiles, or 265 for birds (Fig. 4). 266

In addition to postulating enlargement of the endocranial volume, Russell and Séguin 267 (1982) suggested the presence of anteromedially rotated orbits, a secondary palate, elevated 268 external nostrils and toothlessness, the last feature being deemed advantageous to the 269 avoidance of tooth decay (a rather teleological argument) and thought likely in view of the 270 convergent evolution of toothlessness and "keratinous occlusal surfaces" in the related 271 ornithomimids. An increase in endocranial volume was further suggested to be linked to 272 273 reduction in the size of the face and jaw apparatus, the dinosauroid's skull proportions being based on those of a chick embryo. 274

The dinosauroid was thus intended to be paedomorphic in skull form. While not stated in the text, this was surely inspired by the proposal that humans are paedomorphic with respect to other hominids. Perhaps little-known is that a dinosauroid skull was reconstructed in addition to the life reconstruction (Fig. 5; Russell and Séguin 1982, pp. 24-25). This reveals that both the laterotemporal and mandibular fenestrae were reconstructed as secondarily closed, the quadratojugal eliminated, and the antorbital fenestra was reduced but still present.

The dinosauroid's neck is shortened relative to that of troodontids and human-like shoulders are present, these being braced against the sternum by coracoids as is the case in the animal's ancestors (Russell and Séguin 1982, p. 27). The forelimb proportions are similar to those of ornithomimids, but again the likely impetus for the length of the arm and its segments was that they should be human-like. The hand is tridactyl, the elongate, slender digit I opposing the other two, and all three digits possess nails rather than claws.

In the pelvis, the dinosauroid has broad iliac blades which project laterally, again with reference to the hominid condition. However, Russell and Séguin (1982, p. 26) noted the presence of deflected iliac blades in therizinosaurs as providing a precedent for this condition

in theropods, the 'need' for this condition being "the birth of highly encephalized young". 290 The presence of a navel was deemed evidence for the viviparous birth expected to be present 291 (Russell 1987), though it should be noted that an umbilical scar or similar feature is a 292 widespread trait in vertebrates. A tail is not absent in the dinosauroid but persists as a hyper-293 shortened structure similar to the human coccyx and located between hemispherical buttocks 294 (a "gluteal-like muscle mass"; Russell and Séguin 1982, p. 35), a detail which is rarely 295 appreciated given that most published images of the dinosauroid only show its anterior aspect 296 (Russell and Séguin 1982; their Fig. 18 is the exception). The hindlimbs were again designed 297 298 after those of humans rather than the digitigrade organs of troodontids with their narrow thighs, flexed knees and elongate metatarsi. The dinosauroid's plantigrade feet are 299 tetradactyl, with digits I and II reduced and III and IV longer; all are equipped with nails 300 (Russell and Séguin 1982). 301

On integument, the dinosauroid's exterior is not entirely smooth but intended to be covered in tiny, non-overlapping scales. A dewlap was added as a secondary sexual characteristic (Fig. 2). The colour was based on that of the *Stenonychosaurus*, probably so that they should look as similar as possible.

Russell and Séguin (1982) ended their discussion of the dinosauroid's anatomy by noting 306 awareness of possible bias in its design. Their overwhelming emphasis was on the probability 307 of the evolution of a human-like form among Stenonychosaurus's descendants and their 308 claim that "existing within the spectrum of morphologies represented by terminal Cretaceous 309 dinosaurs was a mosaic of characters which paralleled many seen in mammals and in the 310 phylogenetic precursors of man" (p. 35) is arguable and even objectionable given that we 311 have evidence that troodontids were more like turkeys or hornbills than hominids. Russell 312 and Séguin (1982), though, even wondered whether the dinosauroid might be "too reptilian", 313

and they noted that perhaps the eyes should be proportionally smaller, the ears surrounded by
pinnae, the muzzle less elongate, the chest less deep and narrow (Russell (1987) noted that
the chest should probably have been flatter; he pointed to Slijper's goat – a bipedal individual
born without forelimbs – and tree kangaroos for possible confirmation). The *Syllogeus* paper
also noted that other possible configurations for such a creature might exist. As discussed
later, this invitation has not gone unexplored.

320

#### 321 Building the dinosauroid

Despite its comprehensive discussion of *Stenonychosaurus* and dinosauroid anatomy, Russell and Séguin's (1982) *Syllogeus* paper is unfortunately devoid of data on how Russell and Séguin came to collaborate, and on the physical construction of the two models. Russell (1987, p. 103) includes comments on how the eyes were constructed, but little additional data is included. We are indebted to Ron Séguin for the following information.

From 1973 until the end of the 70s, Séguin was a museum taxidermist and model maker 327 specializing on fish, reptiles and amphibians. The burgeoning popularity of dinosaurs meant 328 329 that now was the time to consider the construction of 3D dinosaur models, and Séguin was the perfect person for the job: Louis Lemieux, then director of the National Museum of 330 Natural Sciences, arranged an inter-departmental alliance, beginning in January 1980, 331 332 between the Exhibits Section and the Research and Collections Department. Séguin's strengths included his knowledge of animal musculature, skeletal form and the overlying soft 333 tissues, his skill in applying resins, paints and finishes in order to make models look like live 334 animals; his sculptural skill; and his knowledge and expertise in the technology and material 335 of molding and casting, this variously involving the creation of metal reinforcements, clear 336

resin eyes and so on. Accordingly, Séguin's initial meetings with Russell did not specifically 337 concern the dinosauroid, but the more general creation of dinosaur models. Russell already 338 had an alliance with artist Ely Kish and was thus well versed in working with artists (Kish 339 produced spectacular colour paintings for Russell's work – most memorably those first 340 appearing in A Vanished World (Russell 1977) and again (this time with other works) in An 341 Odyssey in Time (Russell 1989) and also produced scaled 3D clay miniatures in order to 342 343 understand the interplay between light and shadow on the subjects; see Russell 1987, p. 125). Russell suggested in particular the construction of a Stenonychosaurus model and after the 344 345 creation of a small clay version, Séguin made it clear that producing one at full size would be well within his capabilities. It would prove to be a two-year project. 346 It was toward the completion of the successful and pleasing course of the 347 Stenonychosaurus's creation that Russell began to promote the construction of an 348 accompanying dinosauroid model too, though "he was particularly worried about how the 349 model would be received and the effects it might have on his reputation as a scientist" (R. 350 Séguin, pers. comm. 2020). It would appear that the model came to life through Russell's 351 description of what the anatomy might be like combined with Séguin's knowledge of model-352 making and animal anatomy, and not - remarkably - via the creation of paper sketches or 353 scaled-down prototypes (Figs. 6, 7). The 'real-world' origins of the dinosauroid relate to an 354 355 aspect of it which is seldom discussed: its status as a museum object rather than a hypothesis in the abstract (an area discussed more fully in Burke and Tattersdill, in press). The models 356 underwent several final rounds of revision, particularly with respect to the look of the 357 nostrils, which were initially more vertical than they are in the final product. 358

For Séguin, the creation of the models was very much a challenge, a great experience with an exceptional person, and a career highlight of which he has fond memories. Following the

361 project's completion, Séguin returned to the museum's Exhibit Department and eventually 362 became Head of the Display Preparation Section. Séguin and his team were behind the 363 creation of the three woolly mammoth sculptures which still stand on the museum's grounds 364 today. He left the museum during budget cutbacks in 1993 and succeeded in founding his 365 own freelance model, diorama, and taxidermy company.

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#### 367 Russell and Carl Sagan

To our knowledge, the precise catalyst for Russell's speculations on dinosauroids has never been identified. Given Russell's parallel interests in the evolution and diversity of fossil vertebrates, encephalization and intelligence in the history of life, and the position of humankind in the history of the universe, though, there is likely no one single line of influence. This was an idea which required a combination of scientific arenas and artistic opportunities to come to fruition.

One event which must be considered influential was Russell's visit – presumably of 1965 374 (J. Mallon, pers. comm.) – to the American Museum of Natural History. This is where he 375 376 became impressed with the large brain size coelurosaurian theropods (Psihoyos and Knoebber 1994, p. 251), a realisation which prompted him to spend six weeks during the 377 summer of 1968 in Dinosaur National Park looking for new coelurosaur material (Russell 378 379 1969; Psihoyos and Knoebber 1994, p. 251). Russell's correspondence further reveals that his exchanges with Carl Sagan, initiated in September 1976, were integral to the development of 380 the dinosauroid, Russell's reading of Sagan's The Dragons of Eden (Sagan 1977) being of 381 special importance. The Dragons of Eden - subtitled Speculations on the Evolution of Human 382 *Intelligence* – is a wide-ranging book, its primary thrust being that the complexity, anatomy 383

and function of the human brain is a consequence of our evolutionary history, and that 384 culture, language, politics and human destiny are thus products of our evolution too. On the 385 metaphorical dragons of the book's title, Sagan is vague, at one point stating – shortly after 386 discussing the existence of big-brained theropods and the persistence of big reptiles like the 387 Komodo dragon – "Is it possible that dragons posed a problem for our protohuman ancestors 388 of a few million years ago, and that the terror they evoked and the deaths they caused helped 389 390 bring about the evolution of human intelligence?" (Sagan 1977, p. 141), afterward noting that allegorical reptiles like the serpent in the Garden of Eden might have been references to "use 391 392 of the aggressive and ritualistic reptilian component of our brain in the further evolution of the neocortex" (Sagan 1977, p. 141). On that last point, a pedantic reviewer might note that 393 we synapsids do not descend from reptiles, though this convention had not been adopted 394 when Sagan was writing. 395

Russell's correspondence from September 1976 includes his response to Sagan's request 396 (a telephone call from Sagan's secretary, Christine Bingham) for more information on small 397 theropods. Sagan had seemingly learnt of these animals from astrophysicist Melvin 398 Ruderman. Russell provided a brief outline of his thoughts on saurornithoidids and 399 400 ornithomimids; dromaeosaurids were mentioned in passing. Russell also provided Sagan with a technical paper on Stenonychosaurus inequalis (presumably Russell 1969), another on 401 402 ornithomimids (Russell 1972), a graph (presumably Jerison's) on which the brain : body size ratios of Stenonychosaurus and Dromiceiomimus were plotted, and an illustration of S. 403 inequalis (perhaps a life restoration). We infer that these data were integral to Sagan's 404 discussion of Cretaceous theropods in The Dragons of Eden (Sagan 1977 pp. 135-6); Sagan 405 (1977, 'permission acknowledgements' in unpaginated section) cites Russell (1969) for the 406 407 life restoration of Stenonychosaurus included in the book, but does not list him in the overall

acknowledgements. It was also at this early point in their correspondence that Russell 408 provided Sagan with mostly unpublished data on the hypothesis - developed as a 409 collaborative project with ecologist Pierre Béland and a team of geologists, palaeontologists, 410 physicists and astronomers - that a supernova might be shown to be the cause of the end-411 Cretaceous extinction event. Russell noted his interest in determining the energy and nature 412 of such an event and how it might impact Earth's atmosphere and biota. Besides hinting at 413 414 the idea that Sagan might be able to provide the answers himself (or suggest someone who could), Russell also invited Sagan to a November 1976 meeting on the issue held in Ottawa. 415 416 Sagan was unable to attend, but in September 1976 and again in March 1977 he did at least share some speculations on the supernova hypothesis: Sagan's main observation was that the 417 effects of any such event would be most impactful on micro-organisms, and that "benthic and 418 419 nocturnal animals would preferentially survive". Russell (in a letter of March 11<sup>th</sup> 1977) 420 noted that the fossil record was mostly in agreement with this pattern, but he also drew attention to recently published and in-prep work which showed that extinctions across groups 421 had not occurred in synchrony, and that some stratigraphic data appeared inconsistent with 422 the concept of a sudden extinction event. Of incidental interest is that Sagan sent Russell 423 some of the Viking photos of Mars during September 1976, and that Russell requested a copy 424 of Sagan's Nature article on the Loch Ness monster (Sagan 1976) in February 1977. 425

By June 1977, Russell had received and read *The Dragons of Eden* (Sagan had mailed a copy in May) and wrote to Sagan to congratulate him on the breadth and value of the text. He asked what Sagan's thoughts were on the "evolutionary significance of a Creator as depicted in scripture" and also wondered what Sagan's thoughts might be on whether dinosaur populations were controlled by the availability of energy-rich foods (after all, he reasoned, baby dinosaurs did not have access to the milk provided by mammalian mothers). Given the

details of the Russell-Sagan correspondence discussed so far, it is fair to say that the data
provided by Russell was integral to Sagan's comments on the hypothetical, parallel timeline
evolution of intelligent dinosaurs (Sagan 1977, pp. 135-6) in *The Dragons of Eden*, and such
was confirmed by Sagan in a letter of August 1977. In turn, Sagan's statements likely gave
Russell the impetus he needed to begin the dinosauroid experiment. In other words: Russell
partially inspired Sagan's *The Dragons of Eden*, and Sagan's *The Dragons of Eden* partially
inspired Russell's dinosauroid.

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### 0 The dinosauroid, SETI, and alien evolution

Along with many other influential scientific names (including Stephen Jay Gould, Jonas 441 442 Salk, and Freeman Dyson), Russell was a signatory to Sagan's 1982 open letter in Science advocating the continued funding of the SETI program. In that letter, Sagan notes that though 443 the signatories come from a range of backgrounds, what unites them is the fact that they have 444 all "considered the problem of extraterrestrial intelligence, some of us for more than 20 445 years" (Sagan et. al. 1982, p. 486). Russell's presence therefore implicitly aligns his 446 447 palaeontological work with developing conversations on alien evolution; the next year, he would publish in Advances in Space Research on the subject of intelligent extraterrestrial life 448 (Russell 1983). The SETI letter and the dinosauroid paper, both published in 1982, each 449 450 propose to address an unmanageably vast, even philosophical problem – speculative evolution, alien intelligence - with the careful application of specific disciplinary expertise -451 palaeoartistic restoration and radio astronomy, respectively (for more on the philosophical 452 453 implications of SETI, see Ćirković 2012). They also share, of course, a considerable

454 imaginative appeal which reaches far beyond the scientific institutions where they were455 developed.

456 "But SETI has turned me inside out like a sock!", Russell wrote to radio astronomer Charles Seeger in May 1981. "I used to be content to intimidate little kids with the awesome 457 chasm of geologic time – then you people gently steered me around to fact the great gulf of 458 the future!" (Russell to Seeger, May 4 1981). In the same letter, he offers to send Seeger "a 459 crude plastic model of the skull of Stenonychosaurus as it might have been 76 million years 460 later", this presumably being a version of the dinosauroid skull described and depicted in 461 Russell and Séguin (1982). SETI's emphasis on the evolution of intelligence and the 462 statistical likelihood of a human-like civilization evolving within communication range of 463 Earth inevitably connected it to Russell's interests in the probability or otherwise of 464 humanoids, and so to the dinosauroid project. Indeed, part of the dinosauroid's success in the 465 public sphere might be linked to its superficial similarity to fictional aliens; Russell (1987) 466 noted that the warm reception the model received in some quarters (including from children) 467 may be partly explained to the proximity of the 1982 movie E.T. the Extra Terrestrial. To 468 this day, if the observations of a casual half-hour are anything to go by, the dinosauroid 469 470 currently on display in Lyme Regis's Dinosaurland Fossil Museum ('Saurian', which lacks details present in the original and is of inferior quality), is referred to by visiting families as 471 an "alien" as a matter of routine. 472

Noble noted that the dinosauroid was "given considerable credence" (2016, p. 41) by the
SETI program, but the archive suggests that SETI – itself new and vulnerable in 1982, as the
need for Sagan's letter attests – likely influenced the development of the project as well as
authorizing it after the fact. Russell was discussing the possible existence of intelligent aliens
with NASA personally as early as January 1979, his letters to NASA's Mark Stull involving

discussions of brain size across vertebrates, the causes of mass extinction events ("obviously
of importance to SETI"), and dolphin intelligence. Of special interest is the mention that "it
may be possible to bring a model (flesh-reconstruction) of *Stenonychosaurus* to the June
meeting [presumably a SETI meeting], as well as a hypothetical reconstruction of what it
would have looked like now, had the terminal Cretaceous extinction event not occurred"
(Russell to Stull, Jan 19 1979). "Days have been for admin and manuscripts", he wrote later
in this same letter, "but evenings for SETI until I'm domesticated with a rolling pin".

Russell stated in his 1984 correspondence with Steven Mark that he had participated in 485 two NASA workshops on SETI, quoting his view that evolution may have a directionism 486 which would favour the development of human-like forms: "it could be expected that some 487 biospheres could produce something like what we have called a dinosauroid" (Russell to 488 Mark, April 15 1984). His view is echoed in Russell's (1987, p. 130) statement that "the 489 dinosauroid-humanoid form may have a nonnegligible probability of appearing as a 490 consequence of natural selection within the biospheres of earthlike planets". This, of course, 491 is the deeper link which – at least so far as Russell was concerned – connects SETI to the 492 dinosauroid project: convergence, and the idea that the humanoid form would have emerged 493 inevitably rather than by chance. This is, as we are not the first to observe (Raup 1985; Dixon 494 1988; Paul 1988; Hecht 2007; Naish 2008; Losos 2017), at the back of everything 495 496 dinosauroid-themed (an area we discuss further below). In August 1984, Russell wrote to NYU anthropologist Noel T. Boaz that: 497

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499 500 Cast in the background of the dinosauroid, it seemed like a valid endeavour might be to see how the human form might be a natural target for selective pressures like a fish

form, bird form, etc. rather than a configuration identified by accident in the great
random walk that is organic evolution for some. Steven [*sic*] Gould debunked the
former notion in a recent meeting (June '84) of astronomers interested in the Search
for Extraterrestrial Intelligence in Boston. I think that this was a bit premature.
(Russell to Boaz, Aug 3 1984)

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Gould's position at this SETI meeting would famously be cemented by his 1989 Wonderful 507 Life. Russell's critique, then, anticipates that which would later be made by Simon Conway 508 Morris in 1998's The Crucible of Creation and subsequent works. Gould's primary argument 509 was that evolutionary events operated via contingency and that outcomes would have been 510 511 very different had history gone a different way (Gould 1989); Conway Morris's was that 512 many events were, in fact, at least loosely pre-determined and that animal forms like the humanoid were inevitable (Conway Morris 1998, 2005). The debate between the two became 513 acrimonious (see Conway Morris and Gould, 1998), and its scientific implications are 514 explored at book length by Jonathan B. Losos (2017), who mentions both Russell and the 515 dinosauroid in his introduction (a break with tradition) and conclusion - but nowhere else. 516 Both Losos (2017, p. 8) and Noble (2016, p. 417 n.48) note that Conway Morris has endorsed 517 the dinosauroid more fulsomely than most scientists (he was interviewed in the presence of 518 one in an episode of the BBC documentary Horizon; Everest 2007) but it is important to 519 remember that the issue of evolutionary determinism, in Losos's words, "had not yet been 520 raised when Gould wrote Wonderful Life" (2017, p. 18). Indeed, during the years in which 521 Russell was working on the sculpture, Conway Morris had not yet come to occupy his 522 determinist position and was still writing the papers which Gould would quote in support of 523 his "great random walk". The dinosauroid is, then, an implicit forerunner in the debate 524

around convergence and contingency, not a salvo in it. Russell's archive reveals that he did
correspond with Conway Morris in September-October of 1980; however, the letters we have
examined involve discussion of Burgess Shale organisms (especially *Pikaia*) and make no
mention of the evolution of intelligence, speculative or otherwise.

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530 Ethnology, religion and the dinosauroid

Conway Morris's interpretation of evolution explicitly affirms the existence of a creator. 531 With the dinosauroid, Russell never went so far. He was, though, a committed Catholic, and 532 according to Brian Noble (2016, p. 41), had "long admired the philosophy of Pierre Teilhard 533 de Chardin, and consequently developed an intellectual frame [...] where divinely sourced 534 535 design in organic forms might very likely recur convergently in evolutionary history". Similar comments about Russell's interest in the writings of Teilhard were made by Robert 536 Bakker in an interview about religiosity and science (Campagna 2001). Noble's and Bakker's 537 accounts are based on having known Russell personally; Russell himself seems not to have 538 left any trace of this intellectual frame either in his published scientific works (which, of 539 540 course, could not support it) or in his archived documents. John Acorn (pers. comm., 2020) recalls Russell around 1992 working on an essay about alien-human hybrids which he 541 intended to send to the Church. At the time of writing, though, we are unable to find this 542 543 essay in print, or any mention of it in correspondence. Archives are as important for what they erase as for what they preserve: though many who remember Russell affirm the 544 importance of his faith, cultural and spiritual motivations for scientific work often leave no 545 546 paper trail, and so vanish.

Whilst we cannot report direct evidence of a religious motivation in the dinosauroid 547 project specifically – and have already identified other influences which put it, perhaps, on 548 the wrong side of Occam's razor – the archive does attest to Russell's interest in ethnology 549 and anthropology. During the October of 1981, ethno-historian Rudolph Mitchell Uribe of 550 Flagstaff, Arizona, wrote to Russell with his thoughts on the dinosauroid: he was reminded of 551 a Navajo legend which told of a time when monsters (interpreted by Uribe as dinosaurs) were 552 553 defeated by humans, and he emphasized the possibility that Russell's work may provide verification for the view that humans and dinosaurs had awareness of one another. In his 554 555 response of August 1982, Russell noted how the legend might be "analogous to the parable form in Judeo-Christian tradition" and "could easily be interpreted as containing a deeper 556 truth from the perspective of the current state of our understanding of Earth history". Clearly, 557 he sought to treat an Indigenous position with fair consideration and due respect. But the fact 558 that his immediate recourse was to compare it to the religion to which he was most attached -559 rather than temper or counter these suggestions with a scientific take – might, we suggest, be 560 significant. In this instance, he sought to affirm his correspondent that: yes, it could be that 561 our mythological tales of dragons and serpents might provide insight into a deeper truth, 562 perhaps to our past. This notion is, as described above, hinted at in Sagan's Dragons of Eden 563 (Sagan 1977), not least in its title, and also by Mayor (2000) in her implication that the 564 dinosauroid might play into the mythic archetype exploited by the Ancients in their 565 discussions of Tritons and Centaurs. 566

A criticism of the dinosauroid's design is that its hypothetical evolution does not appear to have been driven by an extrapolation of trends really seen in theropod dinosaurs but, rather, by the expectation that a humanoid form was the inevitable end point for a large-brained bipedal vertebrate. Here we return to Russell's admiration of Teilhard (Bakker, in Campagna

2001, p. 7; Noble 2016, p. 41). A prominent component of Teilhard's philosophy was 571 directionality in evolution, that humans represent a point close to (but not at) the pinnacle of 572 evolution, and that a humanoid stage was inevitable for those organisms approaching 573 evolution's final stage: the field of collective consciousness termed the noosphere, the 574 pinnacle of which was the Omega Point (Teilhard 1959). With admirable generosity to 575 Russell, Losos (2017, pp. 7-8) states: "Remember, Russell did not set out to ask how a 576 577 dinosaur could evolve into a humanoid. Rather, his goal was to think about how selection for increased brain size would lead to other anatomical changes. The end result of this project led 578 579 to envisioning a creature strikingly similar to us, a reptilian humanoid". We submit that this may not be accurate – it seems to be contradicted, for example, by Russell's already-quoted 580 intention "to see how the human form might be a natural target for selective pressures" 581 (Russell to Boaz, Aug 3 1984) – and that the anatomy of the dinosauroid was indeed driven 582 by bias, including that linked to Russell's spiritual perspective on the place of humanity in the 583 universe. This is backed by Russell's implication that humans – and by extension other 584 humanoids - are not simply additional animals (Russell 1987, p. 130; Psihoyos and Knoebber 585 1994, p. 252). 586

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### 588 The dinosauroid and WarGames

Correspondence from Larry Lasker and Walter Parkes of Mandy Films Inc., dated to
October 15<sup>th</sup> 1982, shows that Russell was approached by the makers of the 1983 United
Artists movie *WarGames*. This highly successful and critically acclaimed Cold War movie (a
classic of early 80s cinema) involves the protagonist – student and hacker David Lightman,
played by Matthew Broderick – accidentally hacking the War Operation Plan Response

super-computer and inadvertently triggers it to run a simulated global nuclear conflict withthe Soviet Union.

596 The final version of WarGames includes a segment where artificial intelligence researcher Dr Stephen Falken (played by John Wood) is asked by Lightman (and his female companion 597 Jennifer Mack, played by Ally Sheedy) to return to his previous life at NORAD and help 598 prevent the unfolding catastrophe which the protagonist has initiated. Falken, despondent due 599 to the death of his son, has given up on his research and is not especially concerned to hear 600 that humanity might be extinguished in nuclear conflict, his justification being that extinction 601 is an inevitable part of life on Earth and that humans have had their shot, just as dinosaurs 602 did. He has not just become a recluse, but is now interested in prehistoric animals and not 603 much else: when we first meet him, he is flying a remote-controlled Pteranodon model, the 604 living room of his house features a Dimetrodon skull, Tyrannosaurus and Triceratops 605 models, a wooden plesiosaur skeleton, and more, and he plays a scene from the 1974 film 606 607 The Land That Time Forgot on a projector screen.

Lasker and Parkes's letter reveal that initial plans were to feature the dinosauroid and *Stenonychosaurus* models in the movie, and to show Falken working on them as if they were his current area of interest. Ultimately, the movie did not include any such scene, though it is unknown to us when in the film-making process it was abandoned. It might be argued that the dinosauroid received more than its fair share of publicity and time in the limelight, but had it appeared in this successful, high-grossing film it would have been exposed to an even larger audience.

615 Correspondence also reveals that Russell was approached during August 1983 by Marsh
616 Birchard of the Toronto-based company Enclosure, with plans to make a SciFi film featuring

617 animated versions (seemingly meaning CG animation) of the dinosauroid and

Stenonychosaurus in addition to "documentary footage of work in the laboratory and field".
An April 1985 letter also shows that Phillips-Mark Productions, in charge of making a CBS
documentary on dinosaurs, were hoping to borrow the dinosauroid in May of that year. The
relevant letter reveals that Russell met Phil Tippett in 1984; the precise circumstances of this
meeting are unknown to us but it is likely that they met to discuss the appearance and
behaviour of the stop-motion dinosaurs featured in the 1985 TV documentary *Dinosaur!*,
discussed earlier.

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#### 626 The dinosauroid's legacy

627 In January of 1998, palaeontologist and dinosaur specialist Terry Gates (at the time, an undergraduate student) visited Russell in his office at North Carolina State University and 628 attempted to engage him in conversation on the dinosauroid. Russell politely, but firmly, shut 629 him down, indicated that the conversation was over, and gently encouraged Gates to leave the 630 office. Russell was done talking about the dinosauroid (T. Gates, pers. comm. 2018). By the 631 632 late 1990s, he was unhappy with the reception it had received and may even have been embarrassed by it, so much so that he avoided it in discussion and stopped attending 633 conferences. Ten years earlier, it might have been obvious that things were headed this way. 634 635 A 1983 letter reveals that palaeoartists Sylvia and Stephen Czerkas suggested the creation of a piece of art where 1980s-era dinosauroids were shown working on an artistic reconstruction 636 of their own Paleolithic-grade history. Russell liked this idea, and so did Ely Kish, and a 637 638 grand colour painting depicting exactly this scene was prepared for Russell's 1989 An Odyssey in Time (Fig. 8); Kish also created clay miniatures during her research on the 639

interplay of light and shadow required for the piece (Fig. 9). But, alas, the painting was
excluded from the book and never published. Why not? We surmise that the community's
feelings about the dinosauroid had become clear to Russell by the late 1980s – Russell stated
exactly this in his contribution to *Dinosaurs Past and Present* (Russell 1987, p. 128) – and
that it was this which led him to pare down the book's dinosauroid-themed content.

645 Almost before the Syllogeus article had finished circulating, the dinosauroid had been picked up by Omni (1978-1997), an American magazine which printed both scientific 646 nonfiction and fully-fledged sci-fi. Early in the piece, Russell is quoted saying that the 647 dinosauroid was "actually rather a mundane extrapolation. Meat and potatoes" (Hecht and 648 Williams 1982, p. 50). Despite the prominence afforded this point, Russell's correspondence 649 of 1983 reveals him agreeing with John E. Cronin that the Omni piece was "a bit 650 sensationalist" (Cronin to Russell, Aug 31 1983; Russell agreed in a reply dated September 651 16). These various attempts to downplay the boldness of the project could be part of Russell's 652 character - Omni calls him "self-deprecating" (Hecht and Williams 1982, p. 50) - but they 653 could also be part of the distancing strategy we find him adopting towards the dinosauroid 654 even in Syllogeus (where the dinosauroid is "tentative", Russell and Séguin 1982, p. 2). 655 Russell was honest in print about the criticism the idea attracted from scientific colleagues, 656 one of whom commented that "dinosaur studies today are already characterized by a 657 658 prominent science fiction component" (Russell 1987, p. 127).

Published in August 1984, Harry Harrison's alternate history epic *West of Eden* depicted a war between stone age humans and the Yilané, technologically advanced reptiles who are the dominant society on Earth. Though the Yilané are descended from mosasaurs rather than troodontids, the founding conceit of the K-Pg extinction not happening and evolution proceeding along different lines is one Harrison and Russell shared (Harrison's humans are

evolved from North American primates, not African ones; a fact which plays into Russell's 664 and Conway Morris's ideas of the inevitability of the human bauplan). The novel's artwork 665 (by Bill Sanderson) depicts a version of Yilané which viewers of the dinosauroid would find 666 familiar, although there are also significant differences. We do not, here, advance an opinion 667 as to whether Harrison was directly inspired by Russell's work or whether this is a case of 668 convergence. Though the timing is convenient, it is also true that Harrison had many 669 670 precedents in twentieth-century science fiction to draw on. The pterodactyl-descended Mahars and lizard-man Horibs of Edgar Rice Burroughs's Pellucidar (beginning in 1914), 671 672 Jack Arnold's Creature from the Black Lagoon (1954), the Gorn of Star Trek's 'Arena' episode of January 1967, Doctor Who's Silurians (first seen in 1970) and the Sleestaks of 673 Land of the Lost (first appearing in 1974) are just a few of the examples available to Harrison 674 (Debus 2016, p. 245 helpfully lists others). Perhaps of special potential interest to Russell are 675 the dinosauroid-like creatures of James Blish's 1958 A Case of Conscience, since this award-676 winning story (originally a 1953 novella) pits a man of faith (a Jesuit explorer) against a non-677 religious species with no concept of a god or gods. 678

Was Russell directly influenced by this text? Was the dinosauroid a conscious 679 participation in this sci-fi tradition? We have not seen anything in his archive to suggest that 680 it was, but at the very least we can say that the science fiction potential of his idea was noted 681 682 instantly both by his colleagues and the wider world. The idea that a scientist might support such an idea in a technical study was remarkable and exciting for journalists and the public, 683 but - as demonstrated above - it was seen by some other scientists as lowest common 684 denominator stuff: unworthy, overly speculative, and, especially, unrealistic. The notion of 685 dinosaurs evolving into humanoids is, again, a trope of sci-fi, so it is not surprising that the 686

dinosauroid concept garnered "much friendly abuse from other dinosaurologists" (Paul 1988,p. 397).

However, it is notable is that Russell did not respond to specific criticisms on the 689 dinosauroid's form after the late 1980s. Nor did he ever publicly comment on 'post-690 dinosauroid' speculative projects of the sort he and Séguin invited (Russell and Séguin 1982, 691 692 p. 36). As noted throughout our text, a common response to the dinosauroid's existence is that the underlying premise – that big-brained theropods might or would become humanoid – 693 is fundamentally flawed. This argument was expressed from the moment of the dinosauroid's 694 initial outing (Lovejoy in Hecht and Williams 1982; Raup 1985; Paul 1988) and Russell was 695 aware of it, as demonstrated by his 1984 correspondence with Boaz. But he never responded 696 to it in print. 697

698 The dinosauroid was the first instance of a dinosaur-themed speculative zoology project to appear within literature not regarded as sci-fi; while it can be argued that that other early 699 700 1980s non-sci-fi work of speculative zoology – Dougal Dixon's After Man (Dixon 1981) – also received an amount of discussion and media coverage similar to that of the dinosauroid, 701 this was effectively the first time that scientists, journalists and others were asked to comment 702 on a speculative endeavour outside the proposed existence of aliens. As emphasized above, 703 many have found great similarity in discussions about the possible existence of parallel 704 705 timeline big-brained post-Cretaceous dinosaurs and those about humanoid aliens, and we know (e.g., from a 1979 article in the Globe and Mail (Sullivan 1979), which Russell kept) 706 that both occurred in parallel, sometimes at the same scientific meetings. Beyond the 707 dinosauroid, the next prominent speculative dinosaur-themed endeavour was the sequel to 708 Dixon's After Man, The New Dinosaurs, of 1988. Dixon's parallel-timeline post-Cretaceous 709 world lacks humanoids, nor indeed are there intended to be animals of human-level 710

intelligence (Dixon 1988), as is consistent with statements made about After Man (Dixon in 711 Todd 1981). The New Dinosaurs is, almost ironically, yet another work in which the 712 dinosauroid's appearance heralds the very end of the book, though in this case it would be 713 better argued that it is tucked away in an afterword ('The survival of dinosaurs in literature') 714 and specifically in a section which reviews the interminable 'smart dinosaur' trope of sci-fi: 715 the Yilané, Mahar, and Silurians are all name-checked in addition to the dinosauroid (Dixon 716 717 1988, p. 111). This in itself is interesting: where do you fit, dinosauroid? Are you part of science or science fiction? 718

In internet forum discussions of the early 1990s and beyond, theropod expert Thomas R. 719 Holtz advised interested parties to "avoid the 'roid" (this being a pun based on a 1989 'Avoid 720 the Noid' computer game and advertising campaign used to promote Domino's pizza), and 721 such views were and are common among palaeontologists, palaeoartists and authors 722 specializing on dinosaurs. These were perhaps summarized most effectively by Paul (1988, p. 723 397) who noted that "There are serious problems with the idea", that the model "looks 724 suspiciously human", that the extrapolations about brain size and manual dexterity were 725 poorly founded and too speculative, and that "What bothers me is that dino-hominoid 726 speculation diverted public attention from what is really important about troodontids. These 727 dinosaurs were more birdlike than Archaeopteryx, and were part of the initial bird radiation. 728 729 They were not pseudo-human" (it should be noted that Paul was arguing for inclusion of troodontids within the Archaeopteryx + modern bird clade, hence his reference to them as 730 part of the bird radiation). Consistent with Paul's claim that a supposed 'pseudo-human' 731 interpretation of troodontids might be the main take-home point to some is demonstrated by 732 at least one children's book which inaccurately explains that the dinosauroid represents "a 733 startling model of Stenonychosaurus. [Russell] showed it standing upright, like a human ... 734

People were amazed by this dinosaur which seemed so advanced for its time" (O'Neill 1989.
p. 24). Again, there is no record of Russell responding to these arguments online or in print,
nor is it clear that he was aware of those which occurred outside the published literature (T.
R. Holtz, personal communication, 2020).

A blog article on the dinosauroid, penned by one of us in 2006 (Naish 2006), inspired the 739 speculative creation of a dinosauroid more in line with those of Paul and other dinosaur 740 specialists, namely C. M. Kösemen's Avisapiens saurotheos, a horizontal-bodied, feathered 741 maniraptoran with dexterous jaws. Nothing about it can be described as humanoid. 742 Additional, superficially similar maniraptorans – not all that different in form and proportions 743 from Cretaceous maniraptorans known as fossils - have since been created by other artists, 744 including Simon Roy (Kösemen and Roy have, since around 2008, created an entire 745 speculative world and series of stories about their big-brained dinosaurs) and Mette Aumala 746 (Fig. 10). While these experiments have been discussed in print (Hecht 2007; Naish 2008; 747 Losos 2017), they are predominantly denizens of the internet and have had nothing like the 748 extensive, mass-media reach of Russell and Séguin's project. It should also be clear that these 749 alternative takes on what dinosauroids might be like are not scientific projects, but exercises 750 751 in speculative fiction, albeit conducted by artists highly literate in the scientific discussion. This point again brings us to the fact that it is simply not possible to compartmentalize the 752 753 dinosauroid as either 'science' or 'science fiction': it is rooted equally in Russell's detailed work on encephalization and the tantalizing possibilities suggested by space; it was 754 conducted in close collaboration with a fine artist and arrived almost simultaneously into both 755 genre magazines and technical literature; and its legacy thrives both in fantasy art and nature 756 documentaries. Any assessment of the project's worth, therefore, needs to consider the adroit 757 combination of influences and disciplines, as well as the imaginative bravado, to which it 758

attests – not just the scientific credibility. If the dinosauroid has indeed fulfilled Russell's
expectations and become "a period piece", we can also acknowledge that period pieces can
be arresting, inspirational, and deeply instructive.

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#### 763 Acknowledgements

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#### 915 **Figure captions**

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between 1980 and 1982. The dinosauroid stands 135 cm tall. Dale Russell and Ron Séguin © 918 919 Canadian Museum of Nature. 920 Fig. 2. Ron Séguin's full-sized model of Stenonychosaurus inequalis, created in collaboration 921 with Dale Russell and very literally the ancestor to the dinosauroid model created during the 922 same creative endeavour. Dale Russell and Ron Séguin © Canadian Museum of Nature. 923 924 Fig. 3. The dinosauroid. Dale Russell and Ron Séguin © Canadian Museum of Nature. 925 926 Fig. 4. Log brain (MBr) and body mass (MBd) of dinosaurs, plotted with slopes of brain-927 body equations of non-bird reptiles (lower slope) and birds (upper slope). Polygons surround 928 brain-body point scatters of non-bird reptiles (N = 62) and birds (N = 174), as indicated. 929 Legend: filled triangles, tyrannosaurids; filled diamonds, other theropods; hollow circles, 930 other dinosaurs; ×, dinosauroid. Abbrevations: Al, Allosaurus; An, Edmontosaurus; Br, 931 Brachiosaurus; BAd, Bambiraptor (adult); BJ, Bambiraptor (juvenile); Dp, Diplodocus; N, 932 Cleveland "Nanotyrannus"; Orn, Ornithomimus; Tro, Stenonychosaurus; Trx, 933 934 Tyrannosaurus. Modified from Hurlburt et al. (2003, Fig. 6.3).

Fig. 1. Dale A. Russell with the dinosauroid model, created in collaboration with Ron Séguin

936 Fig. 5. Hypothetical skull of the dinosauroid, as developed by Ron Séguin under

937 collaboration with D. Russell, in lateral, dorsal, and anterior view. Dale Russell and Ron
938 Séguin © Canadian Museum of Nature.

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940	Fig. 6. Behind-the-scenes photographs showing Ron Séguin and colleagues at work on the
941	construction of the Stenonychosaurus and its life-sized skeleton. A scaled-up version of the
942	skeletal reconstruction included in Russell (1969) is visible on the wall. Dale Russell and Ron
943	Séguin © Canadian Museum of Nature.
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945	Fig. 7. Ron Séguin with the initial clay version of the dinosauroid, and Dale Russell and Ron
946	Séguin in discussion while the dinosauroid is being painted. Photos provided by kind

947 courtesy of Ron Séguin.

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Fig. 8. A colour painting by Ely Kish, intended for use in Russell's 1989 book *An Odyssey in Time*. It depicts a 1980s-era dinosauroid pointing to an artistic reconstruction of its own
Paleolithic-stage ancestors. This work was ultimately excluded from the book and has
remained in storage at CMN. Ely Kish © Canadian Museum of Nature.

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Fig. 9. Clay miniatures of dinosauroids in the collection of the CMN, constructed by Ely Kish
in preparation for the painting depicted in Fig. 7. The miniatures depict a Paleolithic-stage
dinosauroid creating art on a cave wall, and dinosauroid parent and child. Ely Kish ©
Canadian Museum of Nature.

- **Fig. 10.** Dinosauroids post-Russell and Séguin. C. M. Kösemen's *Avisapiens saurotheos*
- 960 (below) and Mette Aumala's *Paranthropoharpax naishi*. Both appear with permission of the
- 961 artists.